PLANT PATHOLOGY

A RECORD OF CURRENT WORK ON PLANT DISEASES AND PESTS

Published quarterly for the
Ministry of Agriculture, Fisheries and Food
Plant Pathology Laboratory
Harpenden, Herts

VOLUME 9, No. 3
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THE DIAMOND-BACK MOTH OUTBREAK OF 1958

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ALTHOUGH the diamond-back moth, *Plutella maculipennis* (Curt.), is indigenous to the British Isles and is seen in most years, it is usually considered to be of minor importance and normally causes little damage. Occasionally, however, it reaches epidemic proportions during midsummer and then devastates cruciferous crops.

This sporadic appearance has been referred to by several observers, extending back to Curtis (1860); Ormerod (1891), Harper Gray (1915) and Miles (1924) all reported outbreaks of exceptional severity. Theobald (1926), reviewing the history of these attacks cited 1837, 1851, 1883, 1888, 1891, 1914, 1923 and 1926 as years of heavy losses, 1891 being probably the worst and with the most serious consequences. "In 1891 the damage in the north was so great that it affected the sale of lambs" (presumably due to the loss of root crops on many farms).

Since 1926, entomologists' reports to the Ministry of Agriculture indicate that in 1928, 1941, 1946 and 1949 activity and damage caused by this moth was above normal, but in no way comparable to the scourge of 1891, whereas in the intervening years it caused little damage, a few widely scattered light attacks usually being reported. The only year during the last three decades when diamond-back moth was not reported as causing damage anywhere in England and Wales was 1957.

THE INCIDENCE OF ATTACKS IN 1958 IN THE BRITISH ISLES

Despite the apparent scarcity of the moth during 1957, it is fairly certain that conditions in the spring of 1958 must have been very favourable for the overwintering indigenous population. Reports in mid June suggested unusual numbers present in several areas, Kent, Hampshire, eastern counties and Warwickshire, though there is little evidence to indicate that these were migrants from the Continent. Locally bred moths were also common in parts of Scotland at the end of May and the beginning of June. The northern half of England, including part of the East Midland, the Yorks and Lancs and the Northern regions did not report increased numbers until early July, or first generation attacks. Searches made in the northern counties at the time of intense swarming early in July showed that the first generation was very scarce—occasionally a fully fed larva or pupa was found. However, it is quite certain that the enormous numbers of moths could not have developed locally without leaving more evidence of feeding on crops by larvae during the preceding month. It is considered that in the south of England the first generation was rather more common than usual, but not in the northern half of the country.

Records from five light traps in Kent show that, by the end of April, moths were much more numerous than normal and continued so until the end of June. Even so, the numbers caught hardly sufficed to justify the claim of an influx from the Continent, but the Kentish collector considered that the moths did not arise entirely from the small resident population of the previous year. In Hampshire, too, the moths were abundant during most of June but there is no evidence to

confirm any invasion at this time. It seems likely, therefore, that any movement from the Continent to the south-east coast might well have been masked by the exceptionally favourable conditions for the indigenous population. From Lincolnshire northwards the population of moths breeding during June was quite inadequate to account for the swarms seen in early July, and it is almost certain that the vast majority of those noted in the northern half of the country during the first week of July had come from the Continent.

This sudden appearance of large numbers of moths was most spectacular in the Northern region and Scotland. They were recorded arriving at Aberdeen, in the dockyard, during the morning of June 28 (Hulme, 1959) and on June 29 they were seen independently by several observers on St. Andrews Golf Course, Fife (Jackson, 1958; Mackenzie, 1958). Mackenzie estimated that there were 5–10 moths per square inch (approx. 30–60 million per acre). In a light trap at Kincraig, Inverness-shire (Williams, *in lit.*) moths were caught during every night but four in June, with a sudden rise in numbers on the night of June 29. On the evening of June 30, tremendous numbers were reported simultaneously in all the coastal towns from Berwick to Scarborough. Moths entered houses on such a scale as to cause alarm amongst householders; in the open, cyclists hesitated before riding through swarms; car drivers were obliged to stop and clean their windscreens. So great were the numbers, and so sudden in appearance, that the swarming was a major news item in the local press.

During the following days, enormous numbers were reported inland, away from the coastal belt. On July 2, they were noted in large numbers in the Hexham area of Northumberland, thirty-five miles from the coast, and by July 4 were recorded in swarms in the Carlisle area of Cumberland. Six days after the first report on the east coast, many moths were present over the whole of Cumberland to the west coast. A similar pattern seems to have developed in the Yorks and Lancs region, and by July 2 immense numbers were reported in the Rotherham area and by the end of that week from Lancashire. The invasion reached the Irish coast, near Dublin, on July 2 and extended from Co. Antrim, in the north, to Co. Wicklow, in the south, where they were reported as being present in "clouds" (Baynes, 1959).

These progressive reports from the east to the west of the country add weight to the suggestion that there must have been a mass flight over the North Sea. Furthermore, it should be remembered that both plants and insects generally appear earlier in the milder climate of Cumberland and Westmorland than in bleaker, colder Northumberland and Durham. It is a reasonable assumption then that, had these large numbers emerged from pupae produced in the United Kingdom, the population trend would probably have been from west to east, the reverse of what it actually was. Circumstantial evidence supporting an influx came from the s.s. *Skjelbred*, which was about 25–30 miles off Blyth, Northumberland, on July 1 at 2 a.m., and which reported numerous diamond-back moths entering the wheel-house and other sections of the ship. An even more interesting record is that from the Ocean Weather Ship *Weather Watcher*, which was in position 58° 53′ N 19° 10′ W (about 500 miles west of Cape Wrath and 300 miles south of Iceland). At about 1300 hr B.S.T. on July 4 "thousands" of moths appeared on the bridge, some of which were captured and later identified as *Plutella maculipennis* (Williams, 1958).

On their first appearance the moths were distributed over all fields, but within three or four days they had concentrated their attentions to cruciferous crops. Moth numbers were not assessed accurately, as populations varied from field to field, but some indication of their activity was obtained from a quick survey on swede crops in Northumberland. By July 8 the average number of eggs laid per plant on twelve fields was 157. On July 10, four swede fields examined in the

Carlisle area gave egg counts of 168, 222, 197 and 219 average per plant. It was apparent that a satisfactory hatching would have been a serious threat to brassica and root crops.

THE INCIDENCE IN THE REST OF EUROPE IN 1958

After the moths reached the British Isles, enquiries were made in many other European countries to determine the origin of this vast swarm. Information from France, Belgium and Germany indicated that, whereas the diamond-back moth was common, it was by no means epidemic and that there was no evidence of a mass movement either into or out of these countries. This moth was very abundant in Holland, especially during July, but the numbers were nothing like those seen in the British Isles, and although some observers considered that there was an influx in June, this is by no means certain (Kuchlein, 1958; Lempke, 1959). Moderate numbers were said to be in Denmark during 1957, but certainly not enough to have given rise to the large numbers recorded there in the last days of June and the beginning of July 1958. It was much more abundant than usual in Norway, where it was first observed on June 27 in the southern parts of the country. At the end of June vast numbers of diamond-back moths appeared in the regions of Sweden south of Stockholm and, although no actual migration was noticed, this would appear to be the most likely explanation. In Finland there were many moths in the turnip fields at the end of May, and more emerged at the end of June. During the period June 18–24 many suddenly appeared everywhere and these were thought to have come from the south. In Estonia, where the first moths were noticed on crops about June 20, the 1958 population was said to be very great.

To sum up, it seems certain that France, Belgium and Germany could not have given rise to the great swarm of *Plutella maculipennis* which arrived in the British Isles, neither was there any evidence that these moths had crossed these countries. The same would appear to be true of Holland, with perhaps a faint possibility that the population there was augmented to some extent at the end of June by moths from elsewhere. It seems fairly certain that Denmark was subjected to an invasion, as were southern Norway and Sweden, although probably not on the scale of England and Scotland. High numbers were present in Finland and Estonia, and it appears that the invading swarms had reached these countries also. However, for reasons which are discussed later, these two countries may have been the source, or very near the source, of this invasion.

THE METEOROLOGICAL CONDITIONS

Three distinct points of arrival of this swarm of diamond-back moths are known with a reasonable degree of accuracy both in time and place. They were: O.W.S. *Weather Watcher*, 1300 hr B.S.T. July 4; St. Andrews Golf Course, evening June 29; north-east coast of England, evening June 30. With these three points of origin the Meteorological Office supplied the wind trajectories shown in Fig. 1. These three trajectories show the surface geostrophic winds which arrived at the *Weather Watcher* at 1200 hr July 4, at Kinnairds Head, Aberdeenshire, at 0001 hr June 30 and at Newcastle at 0001 hr July 1 (these are nearest to the times and places of arrival of the moths for which meteorological data is available). The trajectories trace backwards, in time, the path of the wind from each of these points until either the source of the wind is reached or the meteorological data becomes inadequate.

Examination of the three trajectories in Fig. 1 shows certain common features, the most outstanding being their predominantly east–west direction, particularly noticeable in the one to the *Weather Watcher*, and the fact that they appeared

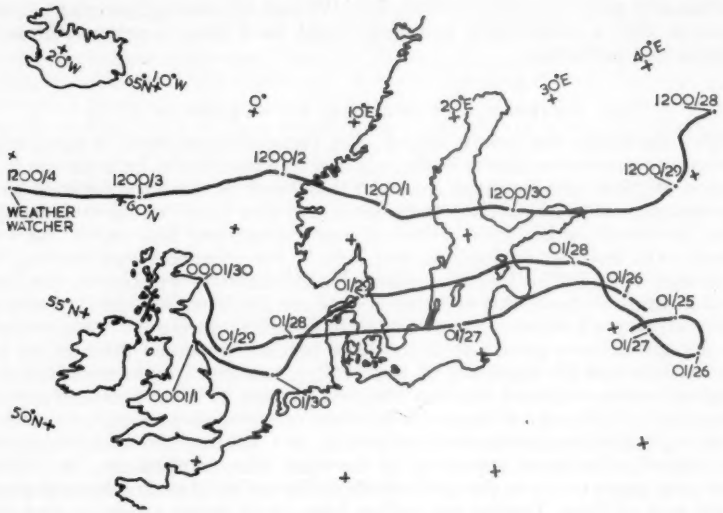

Fig. 1. Wind trajectories from Kinnairds Head on June 30, from Newcastle on July 1, and from O.W.S. *Weather Watcher* on July 4, 1958.

to originate in an area in north-west Russia, approximately between latitudes 55° and 60°N. The only part of these trajectories where the east–west direction was lost occurred where the two most southerly tracks crossed the North Sea, and where the situation was, meteorologically, less definite because wind speed fell. This possibly explains the large numbers that settled on the east coasts of England and Scotland, for as the winds approached the coast line they were reduced in velocity and became more turbulent, thus tending to deposit the

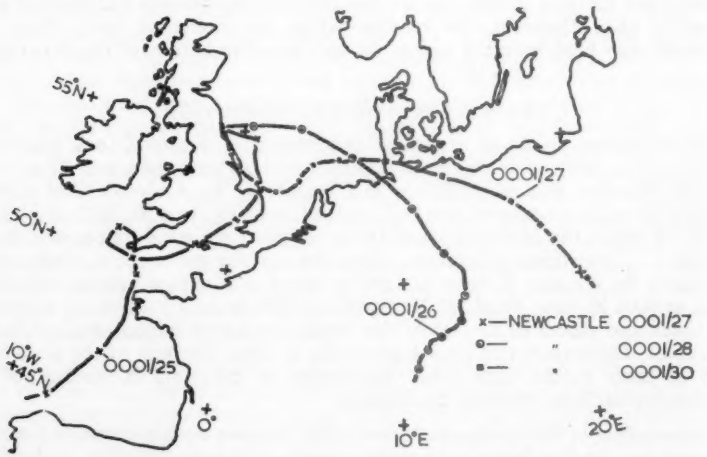

Fig. 2. Wind trajectories from Newcastle on June 27, 28 and 30, 1958.

moths. The tracks of these trajectories, particularly of the two southern ones, agree very well with the reports of the incidence of this insect in the Scandinavian countries, and its comparative absence in other parts of north-west Europe. Other meteorological data link up with the entomological information; for example, the winds arriving at Newcastle at 0001 hr June 27, 28 and 30 (see Fig. 2) all came from a southerly or south-easterly direction (the wind track for June 29 cannot be measured with any degree of accuracy), i.e., they had passed over those regions where the diamond-back moth was not exceptionally abundant. When the trajectories of the air arriving at Kinnairds Head before 0001 hr June 30 are considered (see Fig. 3), it can be seen that the wind arriving at 0001 hr June 27 came from the south, but during the succeeding two days the easterly airstream had become established. There is evidence that some moths did arrive before the vast numbers recorded at St. Andrews Golf Course on June 29 (e.g., at Aberdeen on June 28). As this easterly airstream was slowly spreading southwards, some moths may have arrived in the extreme north-east of Scotland and the Orkneys and Shetlands before June 29. Furthermore, the air arriving south of latitude 53°N on July 1 on the east coast of England had probably come from central or southern Europe, which would account for the fact that moths were few in parts of the east coast other than the north-east.

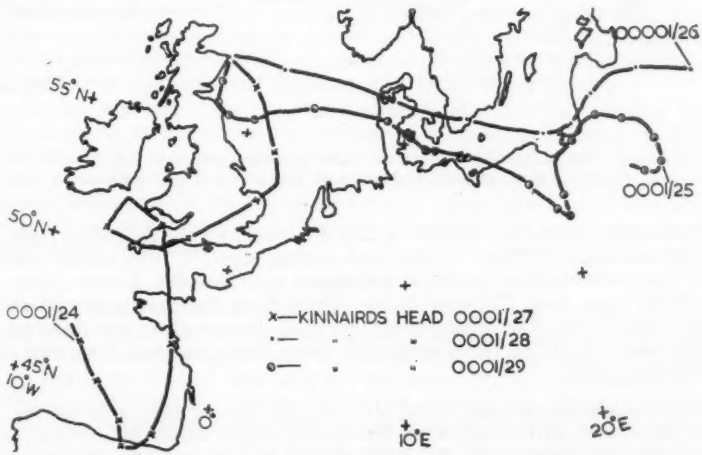

Fig. 3. Wind trajectories from Kinnairds Head on June 27, 28 and 29, 1958.

All these trajectories lead to the supposition that the invading moths originated somewhere in the countries bordering on the eastern shores of the Baltic, i.e., Finland, Estonia, Latvia, Lithuania or perhaps parts of the U.S.S.R. further east.

In an attempt to delineate this area a little more definitely the three trajectories shown in Fig. 1 were considered, not as single lines, but as areas fanning out from their starting points. Thus, although these were the most likely paths that the wind had taken, they were subject to error. The Meteorological Office then provided the fan-shaped trajectories shown in Fig. 4, basing them on an error of estimation of wind speed of $\pm 2{\cdot}5$ knots. In the shaded area of Fig. 4 all three trajectories overlap, and it seems reasonable to suppose that the origin of this swarm of moths was in this overlapping region. The dotted area on Fig. 4 shows where the three trajectories coincide with the region from which the moths are believed to have come. This area is approximately bounded by latitudes 55°

and 60°N and longitudes 25°–35°E, and would appear to be the most likely region from which this mass departure occurred.

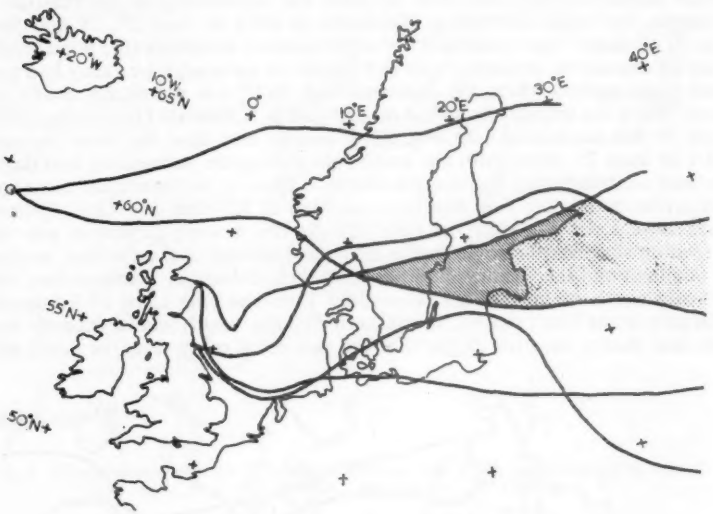

Fig. 4. The limits of error of the trajectories shown in Fig. 1.
Based on an error of estimation of wind speed of ± 2·5 knots.

An enquiry about the weather in this area received the following reply from the Meteorological Office. "In the week ending June 27, 1958, winds were light and there were frequent showers, sometimes with thunder. Temperatures were 60–65°F. From June 27 onwards the winds from the east increased and the storms died down. The temperatures generally increased to give daily maxima in the range 70–80°F. These conditions seem fairly uniform from east to the west of the area."

These conditions appear to be very suitable for the moths to emerge from their pupae and start flying, when the easterly winds would take charge and be responsible for transporting this body of insects over such long distances.

DAMAGE CAUSED BY THE ATTACKS

Attacked crops were reported from all the N.A.A.S. advisory regions, though damage seems to have been rather less in Cornwall, Devon and South Wales than elsewhere. Crops attacked included swedes, turnips, cabbage, Brussels sprouts, kale, broccoli, cauliflowers and the two widely-grown flowers, stocks and wallflowers. Particularly serious damage was caused to late-sown crops, e.g., broadcast kales, some swedes and late Brussels sprouts. Where cauliflowers were well advanced, with curds developing, some growers considered that the damage from larvae was likely to be less than the mechanical injury caused by spraying machinery passing through the crop. This turned out to be an unwise decision as caterpillars penetrated the curds which then became unsaleable. Some fields of early Brussels sprouts were reported as having very slight leaf damage, as the larvae concentrated on and severely injured the sprouts themselves.

Although this pest is considered to be troublesome on sugar beet in Russia, and was reported in 1946 as damaging one such crop in south-east England, no attacks were recorded during the 1958 outbreak. Although moths spread over beet fields, as all other crops, search in the north showed no eggs laid on sugar beet; nor were any larvae found subsequently.

The weather was cool and wet, and many newly-hatched larvae died, yet the numbers remaining were enough to cause appreciable damage. Two cauliflower crops examined in detail for insecticidal trials showed 10·2 larvae per leaf (10–12 leaf stage) in Northumberland and 69 per plant in Holland, Lincs. Most swede crops in Northumberland and Durham had 30–40 larvae per plant. The actual damage caused was considerably less than might have been expected for two principal reasons: the sudden appearance of immense swarms of moths was a major news item, being featured in the local and national press, in the farming periodicals and on the B.B.C.; and the weather conditions referred to above. Because of the publicity, farmers and market gardeners were well aware of the possible threat, and crops were sprayed on a large scale. Paradoxically, had there been fewer moths with less attendant publicity, the damage might have been greater. Outbreaks were quickly brought under control by spraying. DDT was most widely used and with great success though Phosdrin, aldrin, dieldrin and Dipterex all gave some measure of control. Trials in the Northern Region showed that DDT emulsion at 0·1 per cent at 25 gal per acre top spray gave almost complete clearance, and even at 10 gal per acre gave a very satisfactory control. The remarkable efficiency of DDT was confirmed by a trial in the Eastern Region where malathion, Phosdrin and Dipterex were rather less successful.

The larvae resulting from oviposition during the first half of July began pupating in early August and a new generation was produced during the second half of the month, but parasitism greatly decreased the numbers. Two regions reported parasitism at 73 and 80 per cent, and the insects bred out were *Horogenes fenestralis* Gr., *H. cerophaga* Gr. and *Mesochorus* sp. As a result, the larval numbers tended to decrease and by the end of the growing season the damage caused was small.

SUMMARY

In the British Isles, the diamond-back moth, *Plutella maculipennis* (Curt.), is an indigenous, but usually unimportant, pest of cruciferous crops which occasionally reaches epidemic proportions. In spring 1958 it was common in many regions, but at the end of June and the beginning of July it appeared in vast numbers on the north-east coast of England and the east coast of Scotland. Other records come from ships in the North Sea and in the North Atlantic.

The numbers of this insect in Europe were not particularly high in France, Belgium, Holland or Germany, but information from Denmark, Norway and Sweden suggest that these three countries were also subjected to an influx. The same is true of Finland and Estonia, although these countries may well have been at, or near, the origin.

Examination of the meteorological conditions on the operative dates show the existence of suitable easterly winds such as to carry these insects from central Russia to the British Isles and beyond.

From the wind trajectories an attempt is made to define the area of origin of this swarm of insects, and both meteorological and entomological evidence indicates that this was probably in the U.S.S.R.

The damage caused by the larvae was less than was expected because of the use of insecticides, of which DDT proved the most effective, and to the cool, wet weather at the time of egg hatch.

Thanks are due to the N.A.A.S. entomologists who reported their observations and findings, and to Mr. F. H. Jacob for providing access to correspondence between himself and many

entomologists in Europe. We also thank Milton W. Shaw for information from Scotland and Scandinavia. Finally the considerable help of the Meteorological Office of the Air Ministry, in particular Mr. L. P. Smith and Mr. G. G. Leaf is gratefully acknowledged.

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APPLE ROOTSTOCKS SUSCEPTIBLE TO SCAB, MILDEW AND CANKER FOR USE IN GLASSHOUSE AND FIELD EXPERIMENTS

by M. H. MOORE

East Malling Research Station, Kent

APPLE rootstocks make convenient host material for glasshouse and field studies of infection and control of scab, *Venturia inaequalis* (Cooke) Wint., powdery mildew, *Podosphaera leucotricha* (Ellis & Everh.) Salm., and canker, *Nectria galligena* Bres. (Moore, 1947). Malling III and M. VIII have already proved particularly useful for intensive field experiments (Moore, 1952; Moore and Bennett, 1952; 1960), but, as neither is commercially desirable for fruit trees, regular supplies must be specially grown. The relative susceptibility of the readily available stocks was not known, and this information may not be forthcoming from general nursery practice because normal husbandry and annual harvesting, by removing a major source of infection, usually preclude epidemics.

Information is therefore best derived from plants grown for the purpose under conditions in which natural infection is allowed to flourish without fungicide treatment.

HOST MATERIAL IN THE FIELD

In spring 1947, a row of rooted stocks was planted at two-foot intervals in four contiguous blocks, each comprising randomized three-plant plots of the nine rootstocks: M.I, II, III, IV, VII, VIII, IX, XII, and XVI. In due course they formed a hedge, kept about five-feet high and trimmed when necessary. Blocks 1 and 2 were cut down in winter 1949–50 to induce fresh young growth for scab and mildew; 3 and 4 remained to provide sites for cankers.

APPLE SCAB

Infection of the upper leaf-surface was recorded on each plant in blocks 1 and 2 in September 1951. Where possible, the topmost ten leaves of ten random shoots were sampled, and the area of infection was graded into four categories—$<\frac{1}{8}$, $<\frac{1}{4}$, $<\frac{1}{2}$, $>\frac{1}{2}$ surface covered. The results, expressed as mean index of scab severity per plant (Moore, 1952), showed the following gradation:

Stock:	XVI	III	II	VIII	I	VII	XII	IX	IV
Scab:	34·2	15·6	13·3	4·4	3·4	2·3	1·7	1·6	0·0

Favourable infection conditions in early spring 1959 had produced an epidemic on some stocks by June. Each plant was therefore scored in categories (0–5) according to the general severity of foliar infection, and the mean category per plant was:

Stock:	VIII	III	II	XVI	XII	VII	IX	I	IV
Scab:	5·0	1·4	1·0	0·7	0·6	0·3	0·1	0·0	0·0

The four most heavily-infected stocks on each occasion were XVI, VIII, III, and II, but there were inconsistencies. For example, the late-leafing XVI, most heavily infected in 1951, escaped primary infection in 1959 through absence of foliage during a severe infection period when most of the other stocks were between the mouse-ear and green-cluster stages. Only plants adjacent to heavily-infected specimens of other stocks in the random arrangement later showed secondary infection. M. VIII was not well established in 1951, and its relatively light infection was not characteristic of its usual response, as results in 1959 and other experience of this stock have shown (Moore, 1932; Moore and Bennett, 1960). Inspection of the nursery in 1954 (see below) showed that, of the Malling/Merton series, MM. 109 was the most heavily scab-infected; 111 was moderately, and 104 and 106 lightly to moderately infected.

APPLE MILDEW

The number of mildewed young shoots was recorded in blocks 3 and 4 in September 1951, with the following results as means per plant:

Stock:	III	IX	IV	II	VII	I	VIII	XVI	XII
Mildew:	12·5	11·7	5·5	2·5	2·4	1·3	1·3	1·0	0·0

A similar record was made in December 1958 on random samples of 100 shoots per plot in each of the four blocks, with the following results expressed as mean percentages of mildewed shoots per plot:

Stock:	IX	III	IV	I	VIII	II	VII	XII	XVI
Mildew:	44·8	24·0	20·5	18·5	16·3	4·8	3·0	2·0	0·0

The three most heavily-infected stocks on each occasion were IX, III, and IV. M. I and VIII should be included in this susceptible group by reason of their *percentage* infection in 1958, when the disease had become well established.

Assessments of infection in nursery beds were made on other occasions. In October 1954, certain stocks were broadly classified by inspection and random counts after an epidemic that had proved difficult to control by several routine 1 per cent lime-sulphur sprays, with or without 2 per cent magnesium sulphate. Sample estimations along the rows showed the following results:

Percentage of Shoots with Infected Foliage	*Stocks*
50–80	MM. 106
10–25	M. IX, XXV; MM. 109, 111
5–10	M. I, VII; MM. 104
< 5	M. II, IV, XVI

The highest values (80 per cent) among the MM. 106 were associated with the absence of, and the lowest values (50 per cent) with the presence of, magnesium sulphate in the routine sprays*.

In November 1958, a more detailed record was made on some of the stocks in the same nursery. Counts of infected shoots in numerous one-metre sample lengths of row showed the following mean percentages of infected shoots:

Stock:	MM. 104	MM. 106	MM. 111	MM. 109	M. XXV
Mildew:	56·6	46·1	32·2	25·0	12·3

The chief difference from the 1954 rating was the increase of infection in MM. 104, even above that in MM. 106. Evidently seasonal conditions and other factors such as the juxtaposition of stocks in the nursery may influence their liability to become infected, as with scab. There were inconsistencies not only from one season to another but also between sites, notably with M. IV.

APPLE CANKER

Three records of natural infection were made in blocks 3 and 4 in 1952, 1955, and 1958 respectively. Cankers were cut out on each occasion, and the results are shown as mean total number of cankers per plot (3 plants):

Stock:	VIII	III	IX	II	VII	IV	XVI	I	XII
Canker:	121·0	39·5	18·0	15·0	13·3	10·0	5·0	1·0	0·5

M. VIII has already been used in several canker experiments (Moore and Bennett, 1952; 1960).

STOCKS AND INOCULUM FOR GLASSHOUSE EXPERIMENTS

The incidence of disease among varieties in the field is not necessarily a reliable criterion in glasshouse experiments. M. III, for instance, readily infected by scab ascospores from Bramley's Seedling leaves in the field (Moore, 1952), was an obvious first choice for infection experiments on potted rootstocks under glass, yet it consistently showed fleck reaction to ascospores from another Bramley source (Plate III, 1). On the basis of their field record, therefore, M. II, III, VIII, XVI, MM. 104, 109, and 111 were compared in various glasshouse tests under airborne inoculum from Bramley leaves. Invariably MM. 109 yielded most lesions, and the rest, few. This stock, together with MM. 104 and M. III, also became heavily infected with mildew, M. VIII and MM. 111 moderately, and M. XVI lightly infected; M. II was not included in this comparison.

Although the mildew-susceptibility of MM. 109 is inconvenient in scab-infection studies, this stock was readily available and was therefore selected for experiments. Sources of ascospores more pathogenic to the other stocks could probably be found, and M. XVI, apparently resistant to mildew, seems to be a promising host plant. Mixing dead leaves of differing varieties would, in simulating field conditions, improve the prospect of initiating lesions on any one rootstock variety, but would probably increase experimental variability in distributing the effective spores among individual host plants. The use of ascospore mixtures in aqueous suspension might overcome this problem, but ascospore suspensions have not given good results as inoculum in past tests. In experiments for which ascospore inoculum is not necessary, however, fresh conidia in suspension, especially when gathered from living leaves of the same host plant, have given excellent results.

For mildew the choice is not unduly limited because a glasshouse environment generally favours infection from natural sources, though evidently differing degrees

* See also p. 33 of *Rep. E. Malling Res. Sta. for 1954.*

of susceptibility may still be encountered. From the available evidence, M. IV, I, VIII, MM. 111, and especially M. IX, III, MM. 104, 106, and 109, are all promising choices, though M. III, VIII, and possibly I and IV, may not be readily available from usual nursery sources.

DISCUSSION

Field records and general nursery performance showed that, of the apple rootstocks under observation, the following were the most susceptible:

Scab	M. VIII, XVI, III, II: MM. 109, 111;
Mildew	M. IX, III, IV, I, VIII: MM. 106, 104, 109, 111; M. XXV was moderately susceptible;
Canker	M. VIII, III: M. IX, II, and VII were moderately susceptible.

The non-commercial stocks M. III and VIII, hitherto selected for intensive experiments on rootstock hosts, were among the most susceptible to all three diseases, but more readily available stocks can now be chosen in each instance. It is interesting to recall that the foliage of Cox's Orange Pippin was less scab-infected on M. III than on several other stocks (Moore, 1932).

Liability to infection varied to some extent with the circumstances, and led to occasional inconsistencies in apparent susceptibility. General distribution of airborne inoculum from various sources (scab and canker ascospores or mildew conidia) tends to offset any influence of juxtaposition of rootstock varieties *in situ*. With more localized distribution (scab and canker conidia), siting can sometimes assume an important role, as in 1959 when the scab-susceptible M. XVI merely reflected the degree of infection of its immediate neighbours.

In the glasshouse, with chance inoculum, mildew-susceptibility conformed in general to field ratings, but, with a single source of ascospores, scab-susceptibility showed noteworthy defections. It is advisable first to find a source of ascospores well suited to the host plant selected, or vice versa; indeed, ideally, source and host should be identical.

Scab-infection experiments can be hampered by mildew-susceptibility of the host plant, but the hindrance can nevertheless be turned to good account where chemicals are being tested against both diseases.

SUMMARY

Selected apple rootstocks are listed according to their observed susceptibility to scab, mildew, and canker in the field, and to scab and mildew in the glasshouse. The bearing of these observations on intensive experiments under glass is discussed.

I am indebted to Miss Margery Bennett and Mr. R. D. Souter for their help in these observations, and to Mr. A. P. Preston for the 1958 mildew data from the nursery.

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PHENYLMERCURY SALICYLATE RESIDUES IN COMMERCIAL GLASSHOUSE TOMATO CROPS

by H. EGAN *and* R. G. LIDZEY
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Laboratory of the Government Chemist, London

THIS note presents the results of mercury-residue analyses carried out on tomatoes from crops treated with different numbers of applications of phenylmercury salicylate under commercial conditions in 1959.

The present official recommendations for the safe use of phenylmercury salicylate aerosols (revised May 1960)* restrict the use of this chemical on edible crops to aerosol application on tomatoes (under glass), and also set out the conditions of the application. These conditions are such that the residue is unlikely to exceed 0·1 p.p.m. of the phenylmercury salicylate, calculated as mercury, a level which, on present information, is not considered to present a hazard to consumers. The recommendations are:

1. Not more than five applications may be made, at intervals of not less than seven days;
2. The dosage for each application should not exceed 40 mg of organically combined mercury per 1,000 cu. ft of glasshouse space.

The latter dosage rate is equivalent to 1 fl. oz of a formulation containing 0·3 per cent by weight of organically combined mercury per 1,700 cu. ft of glasshouse space. It is at this equivalent concentration that phenylmercury salicylate aerosol fluid preparations are commercially available in Great Britain, and used by tomato growers for the control of leaf mould, *Cladosporium fulvum*, and grey mould, *Botrytis cinerea*. The recommendations are provisional and will be reviewed at the end of 1960.

Mercury residues on commercial crops have been determined in New Zealand by Stone and Clark (1958) using half the above application rate of mercurial. In Great Britain, Beidas and Higgons (1957) examined crops treated with phenylmercuric chloride solution (equivalent to 0·85 fl. oz of 0·3 per cent mercury per 1,700 cu. ft); and Lloyd and Hessayon (*private communication*, 1958) have determined mercury residues after treatment under glass, both of growing crops and of suspended fruit with phenylmercury salicylate applied at the recommended rate and at rather higher rates. The New Zealand workers found that for the whole fruit receiving up to seventeen (half-strength) aerosol treatments the residual mercury content did not exceed 0·075 p.p.m.; for up to ten treatments (nine samples examined) the maximum level recorded was 0·035 p.p.m. Beidas and Higgons found substantially higher residues (up to 0·5 p.p.m.) with phenylmercury chloride following two or more treatments. Using the recommended rate of treatment with phenylmercury salicylate aerosol, Lloyd and Hessayon concluded that the residual mercury on the whole fruit will not exceed 0·1 p.p.m. after five successive weekly applications, although this figure might well be exceeded, either with further applications or with the use of higher mercurial concentrations.

To provide further information for guidance when revising the recommendations, the present work was undertaken at the request of the Scientific Sub-Committee of the Advisory Committee on Poisonous Substances used in

* Obtainable from the Ministry of Agriculture, Fisheries and Food, 5–8 St. Andrew's Place, London, N.W.1.

Agriculture and Food Storage. Arrangements were made in advance of the season by the Plant Pathology Laboratory at Harpenden, in co-operation with a number of N.A.A.S. Horticultural Officers in England and Wales, and with

Results of Analyses

No. of Mercurial Treatments	Rate of Application *fl. oz per* 1,700 *cu. ft*	Residue Uncorrected *Hg p.p.m.*	Residue Corrected (*to* 1 *fl. oz per* 1,700 *cu. ft*)	Tomato Variety	Remarks
0	—	0·010	0·010	—	see text
1	1·65	0·055	0·035	Moneymaker	
	1·13	0·030	0·025	Hertford X	
2	1·02	0·030	0·030	Ware X	
	1·65	0·215	0·130	Moneymaker	*
	1·07	0·050	0·045	Moneymaker	
	1·13	0·035	0·030	Moneymaker	
	1·13	0·030	0·025	Potential	
	1·13	0·020	0·020	Discovery	
	0·54	0·010	0·015	Ware X	
	0·99	0·025	0·025	E.S. 5	
	1·00	0·015	0·015	Moneymaker/ Baby Lea	
3	0·99	0·040	0·040	Ware X	
	1·07	0·025	0·020	Bonne Chose	
	1·02	0·030	0·030	Moneymaker	
	1·07	0·045	0·040	Freedom	
	1·13	0·035	0·030	Potentate	
	1·07	0·035	0·030	Potential	
	1·13	0·030	0·025	Moneymaker	
	1·13	0·025	0·025	Potentate	
	0·54	0·015	0·025	Ware X	
3½	0·93	0·020	0·025	Ware X	†
4	0·93	0·025	0·030	Ware X	
	1·65	0·040	0·025	Moneymaker	
	1·13	0·050	0·045	Moneymaker	
	1·13	0·065	0·060	Moneymaker	
	0·54	0·025	0·050	Ware X	
4½	1·50	0·050	0·035	Cawley's Delic.	†
5	1·13	0·055	0·050	Falcombe	
	0·54	0·080	0·145	Ware X	*
	0·72	0·040	0·055	Moneymaker	
	0·72	0·025	0·035	Ware X	
	0·72	0·025	0·035	Star X	
	0·72	0·035	0·050	Essex Wonder	
6	1·04	0·115	0·115	—	
	1·02	0·095	0·090	Potentate	
	1·13	0·050	0·045	Moneymaker	
	1·13	0·065	0·060	Moneymaker	
7	1·13	0·060	0·055	Moneymaker	†
8	0·99	0·080	0·080	E.S. 1	†
	1·00	0·100	0·100	E.S. 5	†

* Value rejected for diagram, see text.

† Exact number of mercurial treatments uncertain.

the States of Guernsey Horticultural Advisory Service, to receive samples of tomato fruit from growers, together with detailed information concerning the applications of phenylmercury salicylate on the crops from which the fruit was taken. The information included the tomato variety concerned, the date and method of picking, the dates of all previous mercurial treatments with an estimate of the numbers to which each particular sample had been exposed, the rate of application of the mercurial and trimming details. Samples of from 1 to 2 lb of marketable fruit were taken from plants nearest the pathway from which the mercurial aerosol had been applied, placed in polythene bags and sent immediately by post for analysis. Minor modifications to the standard procedure occurred from time to time and are noted in the Table of results below. On receipt the samples were stored, as necessary, at 3°C pending analysis. The whole of each sample received was macerated after removal of the calices and 50 g portions taken for duplicate analyses by the method of Abbott and Johnson (1957).

Results expressed in parts per million of mercury in the whole fruit (rounded to the nearest 0·005 p.p.m. Hg), are shown in the Table. Since the rate of application in practice varied, values corrected by simple proportion to correspond to the standard rate are also listed to enable a direct comparison of individual results: these have been calculated on the original individual values before rounding to the nearest 0·005 p.p.m. mercury. The latter values as a function of the number of mercurial application are shown diagrammatically in the figure.

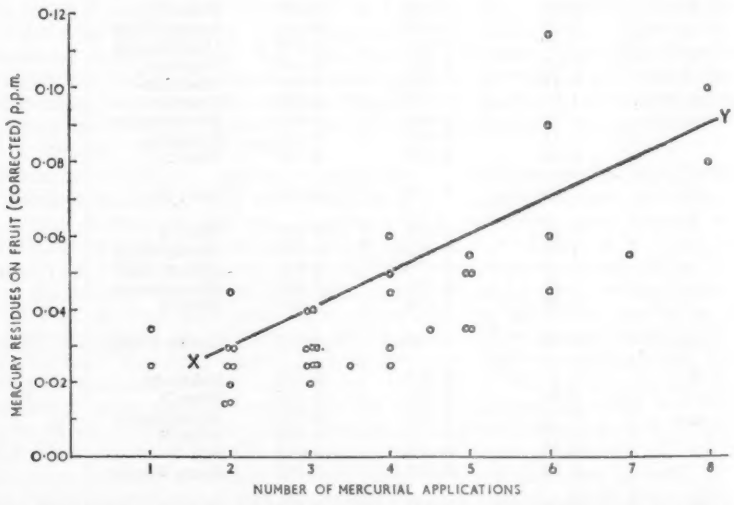

Fig. 1. Relationship between corrected mercury residues on fruit and number of applications. XY = maximum residues to be expected when phenylmercury salicylate aerosol is applied at the recommended rate at intervals of six to ten days (see text).

No control samples were provided with the trial samples but a mean value of 0·012 p.p.m. Hg was found in nineteen determinations on five untreated glasshouse control samples in 1958; two retail samples purchased in 1959 gave a mean value of 0·008 p.p.m. in five determinations. Thus there is a "blank" tomato mercury level equivalent to about 0·010 p.p.m. This small level of natural mercury is probably derived from the soil. Monier-Williams (1949) states that

traces of mercury occur in nearly all foods—vegetables and fruits normally containing 0·005 to 0·025 p.p.m.

CONCLUSIONS

As might be expected, the results suggest a positive correlation between the number of mercurial applications and the mercury residue level (Fig. 1). Two of the highest results (0·145 and 0·130 p.p.m. Hg, corrected) are not plotted in the diagram as, although they were confirmed by repeat analysis, there was evidence of possible external contamination by mercury in these instances. In general it appears that each application of mercury contributes approximately 0·010 p.p.m. Hg to the total residue.

The individual results were obtained on samples from eight regional centres, ranging geographically from Carlisle in the north to Guernsey in the south. Obviously, precise uniformity of husbandry and spraying technique cannot be expected as between individual sites, and there was indeed some variation of application rate (for which a presumptive correction has been made in the Table) and of intervals between successive mercurial treatments by individual growers. No rigid conclusion, therefore, is likely to be possible from the results, but as an approximate guide to the probable total mercury residue (R) from phenylmercury salicylate aerosol, applied at the recommended rate at intervals of from six to ten days, the following convenient, if tentative, relationship may be considered:

$$R = 0{\cdot}01\ (n + 1)\ \text{p.p.m. Hg.}$$

where n, the total number of applications, does not exceed eight. It is clear from the line XY, representing this relationship superimposed on the diagram, that in the majority of instances the total residue is unlikely to exceed the value estimated in this way. Only two samples which had received single applications were encountered in the trial, and the results from these indicate that it would be safer to consider the first application as contributing at least 0·020 p.p.m. Hg in addition to the 0·010 p.p.m. "blank" value.

SUMMARY

Analyses of fruit from forty commercial tomato crops treated with phenylmercury salicylate aerosols in England and Wales and Guernsey in 1959 indicated that, when the aerosol is applied at the recommended rate (not more than 40 mg of organically combined mercury per 1,000 cu. ft of glasshouse space at each application) at intervals of six to ten days, the total mercury residue expressed as p.p.m. Hg on the whole fruit is unlikely to exceed $0{\cdot}01\ (n + 1)$ where n, the total number of applications, does not exceed eight.

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THE EFFECT OF DIELDRIN ON A DIRECT RESEEDED LEY

by D. P. WEBLEY

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IT has been shown (Webley, 1958) that frit fly markedly affects the establishment of a young ley seeded after an arable crop, and that dieldrin sprays can improve the plant establishment by controlling the pest. It was suggested that by killing the *Lolium* grasses the pest changed the botanical composition of the young sward, the poorer grasses taking the place of the good. In 1958, the effect of dieldrin on a direct reseeded ley was studied.

A 4 × 4 Latin square with 400-sq. yard plots was laid down on a field at Ton-yr-efail, Glamorgan, which was direct reseeded after poor mountain pasture with 20 lb perennial ryegrass, 4 lb timothy, 4 lb mixed clovers and 2 lb rape. Four treatments were tested: control; one spray of 15 per cent miscible dieldrin at the rate of $\frac{1}{3}$ gal per 100 gal water, applied on July 11, 1958 when 50 per cent of the young grass had just emerged above ground level; one spray of the same mixture applied on July 25; and two sprays of the mixture applied on July 11 and 25 respectively.

Egg samples taken from the control plots with the Cardiff sampler (Webley, 1957) gave the following results:

	July 11	July 17	July 25
Eggs per 45 sq. inches	27	23	25

The figures agreed with those of the previous year (Webley, 1958), in that most of the eggs were laid on the young grass in the first two weeks after the emergence of the seedlings.

Mean Number of Lolium Touches per 100 Needles

(as $\sqrt{n + 0{\cdot}5}$)

Treatment	Pre-spraying 1958 July 11	Post-spraying		
		1958 Sept. 11	*1958 Nov. 17*	*1959 Jan. 13*
Control	3·1	12·9	13·2	9·0
2 Sprays	2·8	17·1	16·3	9·3
1 Early spray	2·8	15·5	15·7	9·1
1 Late spray	3·1	14·1	13·2	9·1

Least significant difference between any two means ($p = 0{\cdot}01$) 0·81

To assess changes in the botanical composition of the sward, the amount of *Lolium perenne* L. present was used as an index. The grass was estimated by a point quadrat (Brown, 1954) inclined at an angle of 45 degrees. Ten sampling stations were taken per plot, five along each diagonal, and at each point ten pins

were pushed through the frame and the number of *L. perenne* leaves touched was recorded. A pre-spraying analysis was done on July 11, and post-spraying analyses on September 11 and November 17, 1958, and on January 13, 1959.

The results were transformed ($\sqrt{n + 0{\cdot}5}$) and an analysis of variance done. Main effects were highly significant, and so also were the treatment/date interactions. To see whether this was due to differences between treatments before and after spraying, or to changes in the composition of the sward after spraying, the interaction Table was drawn up.

By September the sprayed plots had significantly more *Lolium* present than the unsprayed; further, while the two-spray treatment was only just significantly different from the single early spray, the *Lolium* population on the late spray treatment was only slightly greater than that on the control plots. By the time of the November sampling, the plots sprayed twice and those sprayed once, early, did not differ from each other, but had a significantly greater amount of *Lolium* than the controls and the late sprayed plots. The sampling on January 13, 1959 showed that the differences had then disappeared.

Dieldrin appears to protect the young grass from insect attacks in the early stage of its growth, and the present results indicate that the first spray contributed most to the protection of the young seedlings. This is probably due to the control of frit fly larvae emerging from the eggs laid in the first weeks of the experiment. No soil pests, such as wireworms or leatherjackets, could be demonstrated in any of the plots by the normal advisory assessment methods. Since the second spray was not particularly successful, it appears that it had little systemic action on the larvae within the plants, and also that frit larval migration from the old to new grass was slight at this time of the year, for otherwise one would expect it to have contributed as much as the early spray to the resulting establishment by acting as a barrier to larval invasion.

In this experiment the effect of the insecticide lasted six months. It must be remembered, however, that the management of the ley is of the utmost importance in such a study. In this case, the field continued to be grazed by sheep from August throughout the winter. It is hardly surprising that, by the last sampling date, the animals had cleaned the field bare and evened up the differences observed in the summer months.

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DETECTION OF STEM BORERS IN GRAMINEAE BY X-RAYS

by R. D. GOODHUE* *and* H. F. VAN EMDEN

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FOR some years populations of dipterous stem borers, especially *Oscinella frit* (L.), have been studied at the Imperial College Field Station, Silwood Park, Berkshire, by laborious dissection of the grass stems in five-inch diameter core samples of turf. To reduce the amount of work, while increasing the numbers of samples, and hence the accuracy of the population estimates, a rapid method for sorting infested grass stems is urgently required—a single turf sample often contains several hundred stems. It was therefore decided to explore the possibilities of an X-ray technique.

In view of the low density of stem-boring larvae per unit area in wild grasses at Silwood Park, the tests were done with young oat plants. These had been sown in September 1959, and were known to have been heavily attacked by the oat panicle fly generation which emerged in late July and August. By January 1960 the larvae had reached the third instar, which was thought to be an advanced enough stage in view of the limitations of the X-ray equipment available.

The equipment consisted of a Picker-Waite U.S. Army Field Unit, the tube head of which was mounted to give a vertical film-focal spot distance of 28 cm. To reduce inherent filtration of the X-ray tube as much as possible, the permanent 0·25 mm aluminium filter was removed.

Freshly-collected oat plants were washed free of soil, and the surplus water removed by blotting with a towel. The plants were positioned separately on the surface of the film cassette so that the minimum amount of tissue overlapped, and separated from the photographic emulsion by a 1 mm sheet of black bakelite. Exposures were made on to Ortho-Royal sheet film, which was held in a lead-backed cassette. The best exposure factors for the oat plants were found to be 28 KVp and 30 maS.

After radiography each plant was sketched and dissected, the location of larvae being marked on the appropriate sketch. The sketches were compared with the radiographs, and it was soon plain that larvae of 2 mm or longer could be detected on the radiographs.

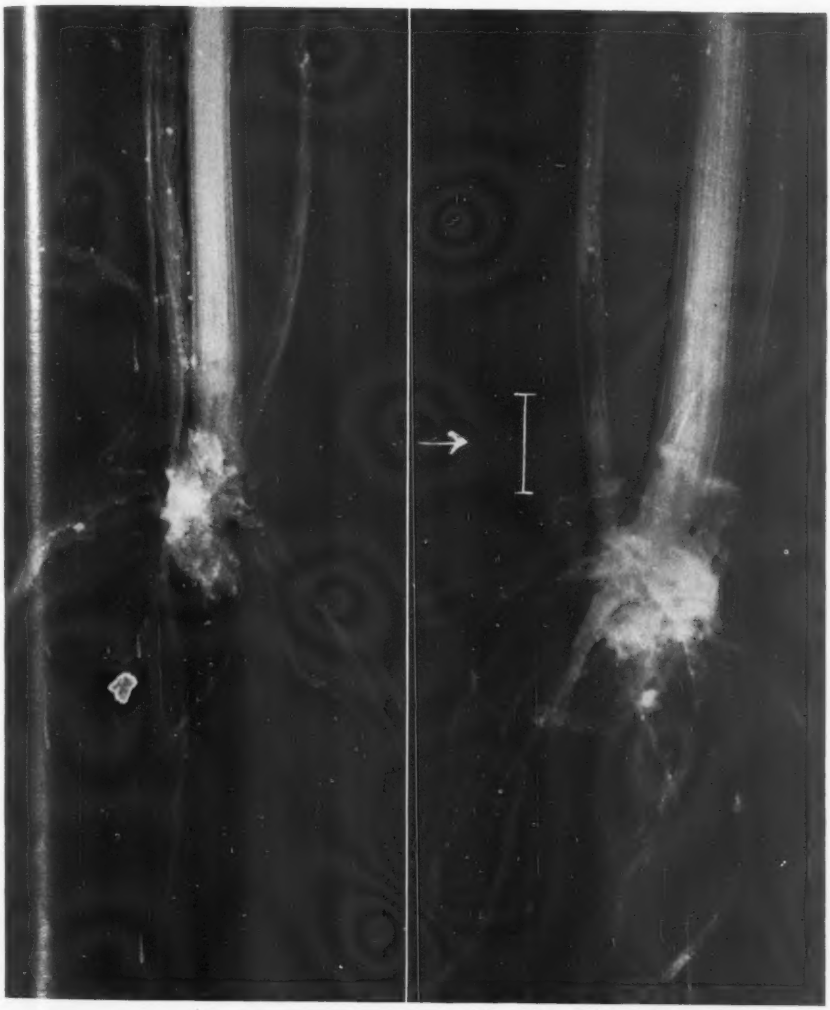
With the limited resolution afforded by the 3 mm focal spot of the X-ray tube, recognition of infested stems depended largely on the air cavity around the boring larvae. This cavity shows up clearly because of the differential absorption of X-rays between air and plant tissue, and can easily be distinguished from the narrower and more regular inter-nodal cavity of the stem (Plate I). Once the air cavity is recognized the larvae can quickly be distinguished.

With the present apparatus it is not possible to guarantee detection of larvae right at the base of stout oat stems where several shoots meet. A second exposure, using more penetrating rays, should solve this difficulty, though the problem will not arise in work on short turf samples for which the method is being developed.

This work was carried out in connection with a research programme supported by the Agricultural Research Council.

* Now at Trinity College, Dublin.

DETECTION OF STEM BORERS BY X-RAYS

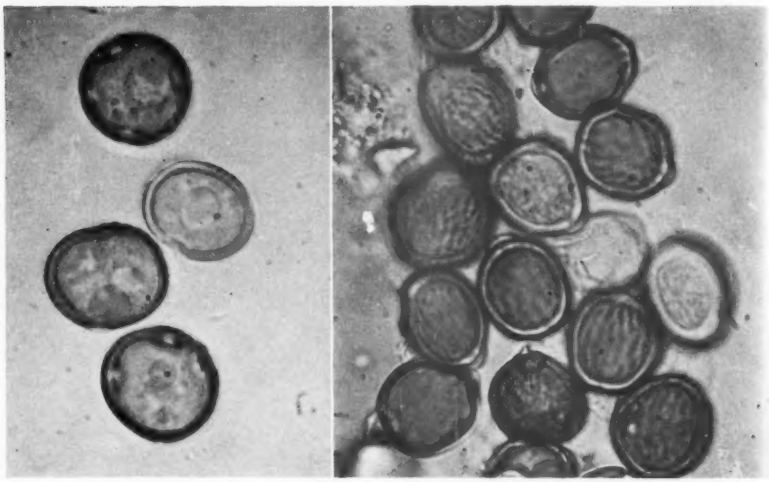


Photos: Imperial College of Science and Technology

Radiographs of oat plants showing (*left*) the appearance of the central internodal cavity in an uninfested plant, and (*right*) the shadow of a larva (marked) and the surrounding air cavity in an infested plant.

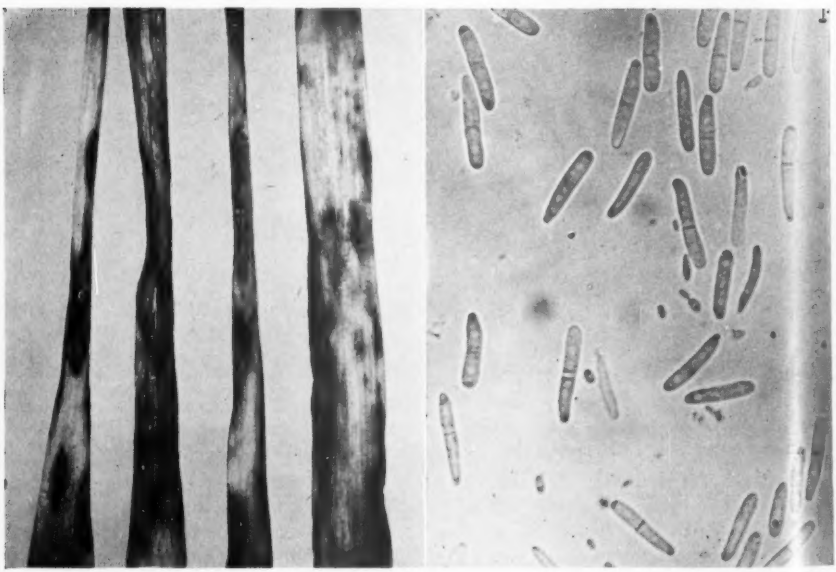
PLATE I

LUCERNE RUST (see p. 111–12)



1. *Left:* Uredospores, and *Right:* teleutospores of *Uromyces striatus* on lucerne. (× 850)

LEAF BLOTCH ON ITALIAN RYEGRASS (see p. 113)



2. *Left:* Typical lesions, and *Right:* conidia of *Rhynchosporium orthosporum* from lesions. (× 560)

APPLE ROOTSTOCKS SUSCEPTIBLE TO SCAB (see p. 84–7)

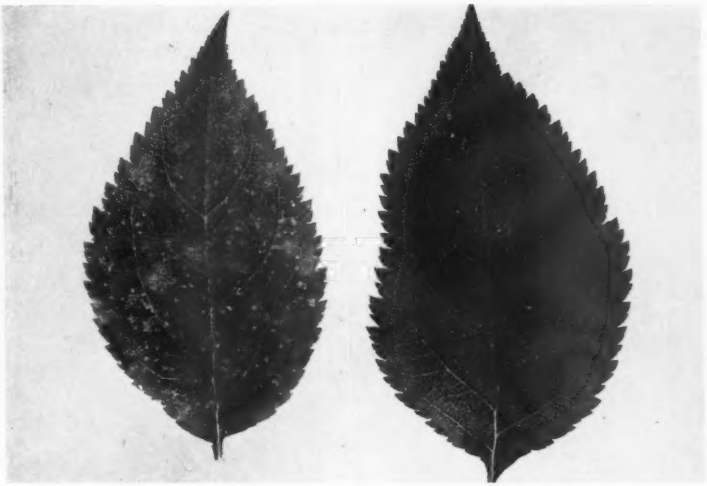
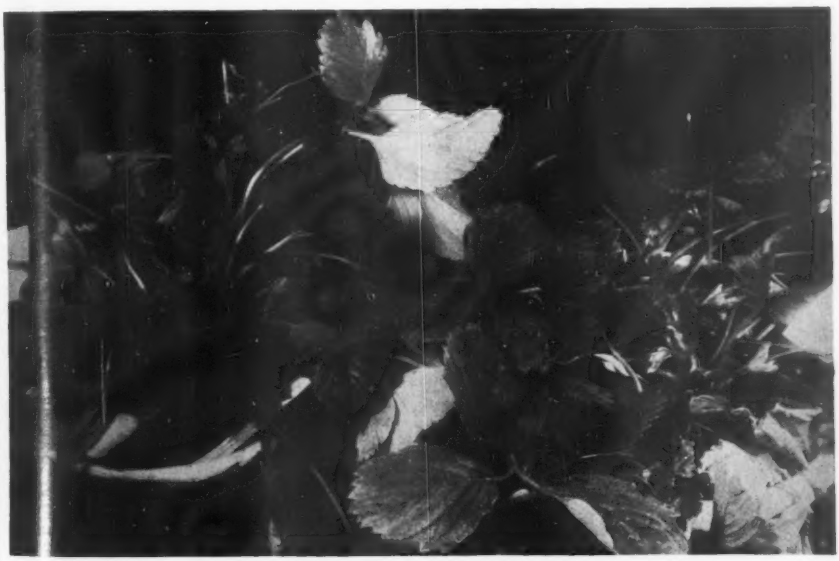


Photo: East Malling Research Station

1. Flecking of M.III rootstock leaf (*left*) after exposure to airborne ascospores from Bramley leaves in the glasshouse; (*right*) unexposed leaf. The larger pallid areas are mildew lesions.

CONTROL OF STRAWBERRY MITE (see p. 114)



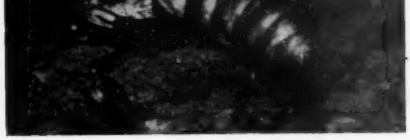
2. *Left:* Plant treated with Thiodan at end of May. *Right:* Untreated control.

PLATE III

THE GARDEN SWIFT MOTH

1. Damage to lettuce.

2. Damage to chrysanthemum.



3. Pupa.

4. Larva.

5. Male moth, *Hepialus lupulinus* (L.).

PLATE IV

OBSERVATIONS ON THE BIOLOGY AND CONTROL OF THE GARDEN SWIFT MOTH

by C. A. EDWARDS* *and* E. B. DENNIS

National Agricultural Advisory Service, Bristol

THE garden swift moth, *Hepialus lupulinus* (L.), is a common soil pest in south-west England. Swift moth larvae are frequently found in garden soils, and they are serious pests in the strawberry and anemone growing area at Cheddar, Somerset, particularly since the summer of 1955 when very heavy infestations were first reported. Serious attacks have also occurred on nurseries growing large areas of such valuable crops as peonies and phlox.

With the exception of the use of naphthalene mixed into the soil, which appears to give only poor control, there is no information available on the control of this pest. This is probably because of the difficulty of assessing mortality of an active soil pest of this kind after experimental treatments have been made, and when the attack is on a valuable crop (Sankey, 1948).

HOST RANGE

Attacks by swift moth larvae have been recorded in the literature on such crops as wheat, oats, grass, potatoes, parsnips, carrots, peas, beans, celery, parsley, peonies, irises, narcissi, daffodils, dahlias, lily of the valley, snowdrops, colchicum, gladioli, lilies, auriculas, delphiniums, chrysanthemums, strawberries, hops, and raspberries; they are also common at the roots of weeds such as docks, dandelions and nettles.

In south-west England, during the past ten years, attacks have been seen on swedes, celery, lettuce, wheat, chrysanthemums, phlox, anemones, Michaelmas daisies, strawberries and raspberries. It seems probable that the larvae will attack almost any plant with a fleshy or woody root system.

NATURE OF DAMAGE

The greatest damage to crops occurred in late autumn, winter and early spring, and the larvae remained active throughout the cold weather. Attacks were characterized by a patchy distribution of damage, which is probably due to the discontinuous distribution of the larvae over the infested area. The distinct areas of damaged plants in the crop enlarged very slowly, which indicates that there was only limited lateral movement by the larvae through the crop. Some movement down the rows occurred, however, when the crop did not supply sufficient food from a single plant, for example in lettuce, resulting in bare patches in the crop. Here damage took the form of bites through the base of the stem (Plate IV, 1), but in crops with a fleshy or woody base, larvae tunnelled leaving a semi-circular cavity. In chrysanthemums the larvae may burrow a considerable way up the stem, or may strip the peripheral tissue from the base of the stem (Plate IV, 2).

LIFE CYCLE

Observations were made principally on anemones attacked in the spring of 1958, and on lettuce attacked in the early spring of 1959. In general the larvae pupated in early April, although occasional pupae (Plate IV, 3) were found as

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early as January in 1959, and even at the end of April in 1958 there were some larvae still to be found. Pupae were brought back to the laboratory in 1958, and some were kept at room temperature and others outdoors. Indoors there was an emergence of adults (Plate IV, 5) in early March, but outdoors the first emergence occurred near the end of May. It was noted that after the moths had emerged the pupal case remained protruding from the soil.

Egg laying began soon after emergence, but fertile eggs were not obtained, as male and female moths were not available at the same time. Over 200 eggs were laid by a single moth, and the eggs were slightly elongated, 0·5 mm in diameter, smooth, round and whitish when laid, later turning black. The eggs appeared to be dropped at random while the moth was caged.

The larvae (Plate IV, 4) are active and burrow away from light, although they were actually seen moving over the surface of the soil. There is some confusion in the literature over the length of the life cycle, but in the present work larvae found during the main feeding period from autumn to spring were all of similar size in a wide range of attacks, evidence that in most cases the life cycle was completed in a single year. In none of the attacks studied were young larvae found in the field. The numbers found around the roots of a single plant varied very considerably, but could be related to the size of the root system. It was noted that a crop such as peonies could maintain as many as twenty larvae, while a single larva killed several lettuce plants. Larvae of the garden swift moth were found together with those of other swift moths in some attacks, in particular with larvae of the ghost swift moth, *Hepialus humuli* (L.).

There appeared to be a very considerable natural mortality of the larvae, and many were killed during cultivation of the soil. They are susceptible to attack by parasitic fungi, and in the Cheddar area numerous dead larvae were found attacked by a species of *Candida*, a saprophytic fungus.

TRIALS IN 1958 AND 1959

In March 1958, a trial was laid out on a large anemone bed which had been badly attacked by swift moth larvae. Treatments were applied as a soil drench, by means of a large watering can, at a rate of approximately ½-pt. of insecticide solution per plant. There were six single row replicates of four different insecticidal treatments and control, laid out in randomized blocks. Each of the insecticides incorporated a wetter. The effectiveness of the treatments was estimated by digging up the entire bed one month after treatment and counting the numbers of live and dead larvae found. Relatively few larvae were found at this time, however, and the results (Table 1) gave only a preliminary indication of the relative effectiveness of the treatments.

TABLE 1

Control of Swift Moth Larvae under Anemones

Insecticide	Concentration of Soil Drench *per cent*	No. of Live Larvae per 50 ft of Row	Approx. Cost per 100 gal
DDT 20 per cent emulsion ..	0·05	0·4	8s.
gamma-BHC 10 per cent miscible..	0·01	0·5	12s. 6d.
Dieldrin 15 per cent miscible ..	0·03	1·0	15s.
Aldrin 30 per cent miscible ..	0·1	1·4	40s.
Control	—	2·0	—

This work was followed on December 10, 1958, by a trial on a much larger scale, on a site where half an acre of lettuce had been severely attacked. This attack was on land that had grown strawberries until August 1958, and then was planted with winter lettuce. The layout was similar to that in the previous trial, with four replicates of four insecticidal treatments and control; each replicate consisting of 150 yards of row. The insecticides and concentrations were the same as in the first trial, but in this case there was heavy rain soon after treatment so that the insecticides were washed well into the soil around the plants. The mortality of the larvae was estimated by digging up attacked plants on four occasions following treatment, the final samples being taken on February 9, 1959. At the same time counts were made of the numbers of damaged plants. Results are summarized in Table 2 and Figs. 1 and 2.

TABLE 2

Control of Swift Moth Larvae under Lettuce

Insecticide	Concentration of Soil Drench *per cent*	Mean No. of Live Larvae per 150 yards of Row	Standard Deviation	Mean Kill *per cent*
DDT 20 per cent emulsion ..	0·05	18**	5·7	66·0
gamma–BHC 10 per cent miscible..	0·01	26**	11·4	51·0
Dieldrin 15 per cent miscible ..	0·03	38*	18·6	28·0
Aldrin 30 per cent miscible ..	0·1	34**	3·7	32·0
Control	—	53	10·1	—

Least significant difference (p = 0·05) 11·6; (p = 0·01) 16·2.

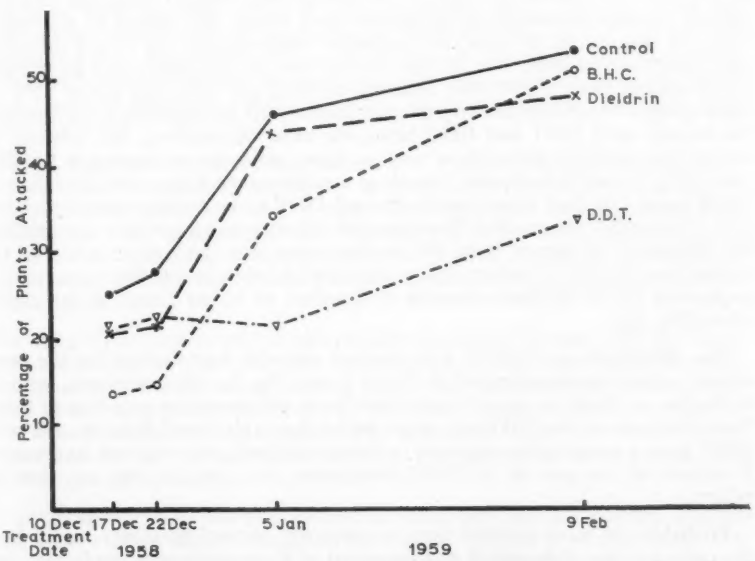

Fig. 1. Percentages of lettuce plants attacked in 1958–59 trial.

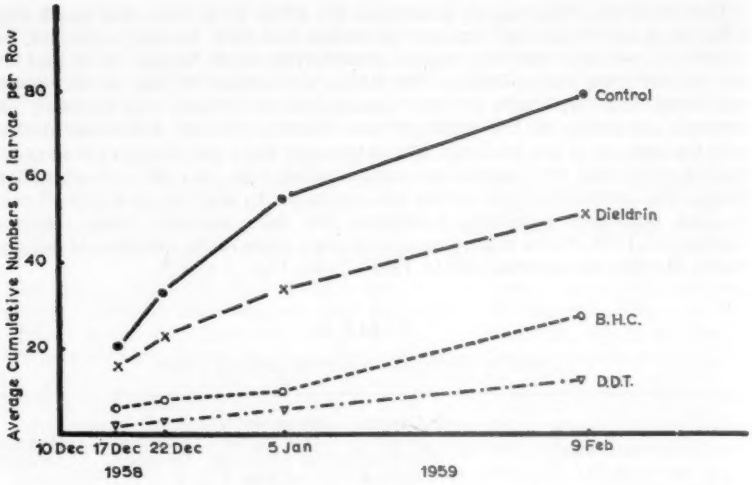

Fig. 2. Cumulative numbers of live larvae for 150-yard row in trial on lettuce, 1958–59.

DISCUSSION

The first trial gave a preliminary indication that DDT and BHC soil drenches were likely to be the most effective treatments to control the larvae in soil, and stop the progress of an attack, but the numbers of larvae involved were small. Further, it did not give any information on the development of an attack because, at the time of treatment, most of the larvae were almost fully fed and little further damage occurred. In the second trial, where only about 10 per cent of the crop was damaged when the treatments were applied, the attack developed and after two months over 50 per cent of the lettuce plants had disappeared in the control rows. This attack occurred earlier in the year, and larvae were still feeding when the final counts were made. Initially all the insecticides used reduced the attack, with DDT and BHC being the most outstanding, but towards the end of the sampling period there was increased incidence of damage in the BHC rows (Fig. 1), which indicated that these treatments were less persistent than the DDT ones. The final plant counts showed DDT to be considerably better than any of the other treatments. The apparent effectiveness may have been reduced by migrations of larvae from the control rows into the treated ones, so that actual control may be better than is indicated by the counts. This conclusion is supported by the gradual decrease in numbers of larvae found in the control rows (Fig. 2).

The effectiveness of DDT as a control material was verified by the larval counts, which are summarized in Table 2 and Fig. 2. All treatments, with the exception of dieldrin, gave highly significant differences in numbers of larvae from the control, but DDT was much better than aldrin and dieldrin; and while BHC gave a good initial decrease in larval numbers, this was not maintained. Furthermore the cost of the DDT treatments were considerably less than the others.

Probably the most suitable time to carry out control measures would be in the early autumn, if an attack was suspected or if young larvae were found, since the young larvae are probably more susceptible to the treatments than the older

ones. The habits of the moths make control at this stage difficult, and hence soil treatments to control the larvae are the more practical.

SUMMARY

Biological observations on the garden swift moth in south-west England are reported. There is evidence that this moth has a one-year life cycle. Chemical control trials in 1958 and 1959 indicated that DDT soil drenches gave good control.

Thanks are due to Mr. J. Mayor for assistance in carrying out the counts and taking the photographs, and to Mr. J. Pearce and Mr. J. White of Cheddar, Somerset, for providing the experimental sites and considerable assistance in sampling.

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SIZE OF POTATO TUBERS AND NATURAL INFECTION WITH BLIGHT AND PINK ROT

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IN the course of experiments on the effectiveness of commercial protective spraying in reducing tuber blight in 1957, it became clear, especially with the variety King Edward, that the proportion of blighted tubers varied with the size of the tubers. This was confirmed by tuber counts of random plants in a number of fields both of King Edward and of Arran Pilot. No such indication was given in two crops of Majestic, although in all these cases individual samples were only of the order of 150 tubers.

In 1958, the produce of 8–10 samples, each of 5 yards in length, was examined in six fields, or variously treated areas of fields, of King Edward and one of Majestic in South East Scotland. Samples were taken just before harvest after the haulm had been dead for several weeks. In 1959, the same procedure was adopted in one crop of Kerr's Pink and three plots of Catriona. Several other crops of King Edward and Arran Pilot sampled in the same way showed no blighted tubers.

The sample tubers were placed into the size categories of ware, seed and chats by eye assessment in the field. The critical sizes between the categories were $2\frac{1}{4}$ inches and $1\frac{1}{4}$ inches respectively, as these sizes represent the normal limits of seed potatoes. In each case about 1,000 tubers were examined, the blighted tubers in each category being counted. The results are shown in Table 1, which includes data on the approximate dates of the first appearance of blight, and the final death of the haulm.

It would appear that in certain varieties at least, such as King Edward, smaller tubers show a much higher susceptibility to blight than larger ones, i.e., seed is more susceptible than ware. This is in the inverse ratio to the surface area, an approximation of which might be taken by considering round tubers of average

diameters of 3 in., 2 in., and 1 in. for ware, seed and chats respectively, which have a surface area ratio of 9 : 4 : 1. In the crops examined, the proportion of seed to chats was always between the approximate ratios of 3 : 1 and 3 : 2. The numbers of ware tubers varied greatly, in some cases being more than those of chats and in others exceeding the 1 : 9 ratio with chats, but this did not appear to influence infection differences. Variation in infection cannot thus be related to the area of tuber surface available for infection. Although the haulm of King Edward is very susceptible, infection was by no means confined to heel-end penetration by way of the stolons, which might have accounted for higher blight incidence in the smaller tubers. In any case a number of other varieties react in a similar way.

TABLE 1

Incidence of Tuber Blight in Relation to the Size of the Tubers

Variety	Field No.*	No. of Spray or Dust Applications	No. of Tubers and percentage Blighted						Dates of	
			Ware		Seed		Chats			
			No.	*per cent*	*No.*	*per cent*	*No.*	*per cent*	*0·1 per cent Blight*	*Haulm Death*
1958										
King Edward	1	3	320	1·3	637	3·5	201	15·5	15/8	9/9
		4	341	3·8	791	8·5	241	19·5	15/8	9/9
	2a	1	40	0·0	764	9·6	269	21·9	5/8	23/8
		3	46	6·5	687	8·9	274	16·1	5/8	27/8
	2b	0	33	9·1	690	12·5	341	30·8	8/8	26/8
		3	23	8·7	495	12·5	313	26·2	8/8	31/8
Majestic ..	3	0	353	2·3	814	1·4	420	1·7	4/8	2/9
		3	302	1·0	847	0·8	355	1·7	12/8	5/9
1959										
Kerr's Pink	4	2	646	0·2	1224	1·6	394	2·3	—	—
Catriona ..	5a	0	43	0·0	532	0·6	373	0·5	6/8	26/8
	5b	0	61	1·6	439	2·3	195	8·7	3/8	26/8
	5c	0	20	0·0	453	0·7	324	2·2	21/8	—

* 2b planted ten days later than 2a.
5a planted March; 5b, April; 5c, May.

Table 1 indicates that spraying or dusting on King Edward in 1958 was not very effective in reducing tuber infection. Indeed in Field 1, the final dusting was carried out when haulm blight was at the 0·1 per cent stage and the incidence of tuber blight was increased. In Field 2, the incidence of tuber blight was higher in the lower yielding plots where planting had been delayed by about ten days. Here the tubers might have been expected to have been less mature at the onset of blight, although this appeared a few days later than in the earlier planted area. In Field 5, in 1959, blight appeared last on the last planted plot, but very quickly dried up.

Susceptibility to blight in relation to tuber size may depend on the relative maturity of the tuber at the time of spore contact, as maturity has been shown

to influence blight infection (Boyd and Henderson, 1953). Further work is necessary to determine why the variety Majestic has not been found to follow this pattern.

TABLE 2

Incidence of Pink Rot in Relation to Size of the Tubers (King Edward)

Field	No. of Tubers and percentage with Pink Rot					
	Ware		Seed		Chats	
	No.	*per cent*	*No.*	*per cent*	*No.*	*per cent*
1	440	4·8	1247	4·8	835	1·8
2	416	1·0	1219	0·8	722	0·1
3	429	7·7	1307	1·5	727	1·4

Tuber susceptibility to blight in relation to size is therefore different from susceptibility to dry rot, *Fusarium caeruleum* (Boyd, 1952), and to skin spot, *Oospora pustulans* (Boyd, 1957), where large tubers show highest susceptibility. It appears also to be different from susceptibility to pink rot, *Phytophthora erythroseptica*, for which the figures in Table 2 were obtained in 1959 for the variety King Edward, using the procedure described above. Here again ware tubers showed highest susceptibility.

SUMMARY

Crop samples of some potato varieties, particularly King Edward, in south-east Scotland, showed that the proportion of blighted tubers was consistently highest in chats and lowest in the ware fraction. This may have been related to the degree of maturity of the tubers at the time of spore contact; and is the opposite of the relationship found with pink rot where the larger tubers were the most frequently infected.

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OCCURRENCE OF SOIL-BORNE VIRUS DISEASES OF STRAWBERRY IN BRITAIN

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THE soil-borne ringspot viruses, raspberry ringspot, tomato black ring (= beet ringspot) and arabis mosaic (= raspberry yellow dwarf) have similar biological and physical properties, and affect many different kinds of weed and crop plants (Harrison, 1960). Arabis mosaic is transmitted by a nematode, *Xiphinema* sp. (Jha and Posnette, 1959; Harrison and Cadman, 1959), but no vectors are yet known for the other two viruses. In 1958, I reported that raspberry ringspot and arabis mosaic viruses were the cause of severe diseases of local importance in several varieties of strawberry in western and eastern Scotland and in southern England (Lister, 1958). Since then, many indigenous outbreaks of raspberry ringspot and tomato black ring viruses have been identified in strawberry plantations in Scotland (Lister, 1960a, and unpublished), and the diseases caused are now recognized as a serious problem, particularly in strawberry propagation and certification.

The importance of the problem elsewhere was not so clear, but as strawberry samples sent here from various other parts of Britain proved to be infected with strains of arabis mosaic virus, it seemed likely that soil-borne virus diseases were also widespread in strawberry elsewhere in Great Britain. Thus in May 1959, an attempt was made, in collaboration with officers of the N.A.A.S., to obtain some information on the incidence and importance of soil-borne virus diseases in strawberry-growing areas in England. The areas visited were Wisbech, Kent, Hampshire, Combe Martin (Devon), the Tamar Valley (Devon and Cornwall), Cheddar, the west Midlands and the Dee Valley. Strains of arabis mosaic virus were isolated from strawberry collected in all these areas except Wisbech, as shown in the Table.

METHODS

As well as inspecting plants *in situ*, leaves, and sometimes plants, were collected and subsequently tested at Mylnefield for the presence of ringspot viruses by rubbing extracts obtained by macerating leaves with water, alumina and Celite on to the leaves of *Chenopodium amaranticolor* Coste & Reyn. Where indicated, soil samples were tested by the use of bait plants as described by Cadman and Harrison (1960).

All the viruses isolated caused systemic chlorosis in, and distortion of, the tip leaves of *C. amaranticolor:* some isolates also caused local necrotic lesions in inoculated leaves. As both kinds of symptom can be caused by strains of either tomato black ring or arabis mosaic viruses, the isolates were identified by means of two serological methods, developed and now used as a routine at this laboratory (Lister and Bulloch, unpublished). In one (method 1 in the Table), crude sap from the tip leaves of systemically infected *C. amaranticolor* was allowed to react with standard antisera to the viruses by double diffusion in agar, the isolate being identified by the specific precipitation lines formed. This method works very well with strains of arabis mosaic virus, but only moderately or not at all with tomato black ring virus. In the other (method 2 in the Table), the isolates were characterized by the specific abolition of infectivity which occurs when diluted sap is mixed with suitable dilutions of the standard antisera.

Arabis Mosaic Virus Infections from Strawberry in England, May 1959

Area	No. of sites visited	Soil type at sites of infections	No. infections/ No. samples	Variety	Identifications* *Method 1*	*Method 2*
Wisbech ..	6	—	0/9	—	−	−
Kent	8	heavy loam	1/11	Favourite	+	−
Hampshire ..	14	medium shingle	14/20	Prizewinner	−†	−
				Vigour	+	+
				Favourite	+	+
				Talisman	+	+
				Talisman	+	+
				Talisman	+	+
				Favour[illegible]	+	+
				Rival	+	+
				Vigour	+	+
				Talisman	+	−
				Vigour	−	+
				Talisman	+	+
				Talisman	+	+
				Vigour	+	−
Combe Martin (Devon)	3	medium loam	1/2	Favourite and Vigour	+	+
Tamar (Devon)	1	heavy loam	4/5	Vigour	+	+
				Vigour	+	+
				Redgauntlet	+	+
				Favourite	−	+
Tamar (Cornwall)	7	heavy loam	4/11	Prizewinner	−	+
				Prizewinner	+	+
				Prizewinner	−	+
				Prizewinner	+	+
Cheddar ..	3		1/6	Favourite	−	+
West Midlands	6	sandy loam river gravel sandy loam	3/11	Favourite	−	+
				Talisman	−	+
				Royal Sovereign	+	+
Dee Valley ..	8	poorly drained sand	5/12	Talisman	+	+
				Talisman	+	+
				Talisman	+	−
				Unknown	+	+
				Redgauntlet	+	+

* Methods of identification are explained in the text.
† Isolate lost.

OBSERVATIONS

Wisbech area. Several patches of dwarfed plants were seen, some of which were clearly associated with red core disease (*Phytophthora fragariae* Hickman). Others were very suggestive of infection with soil-borne viruses, but no mechanically transmissible viruses were isolated from any plant samples.

Kent. In the samples collected, the only infections confirmed were of arabis mosaic virus in those from a field of Cambridge Favourite, where the distribution of infected plants suggested the presence of infective soil. Indigenous outbreaks of arabis mosaic virus have also been recorded elsewhere in Kent (Harrison, 1958).

Hampshire (north). Only one farm was visited: virus was isolated from one of a group of stunted Cambridge Prizewinner plants collected there. The symptoms caused in *C. amaranticolor* were typical of arabis mosaic virus, but the isolate was unfortunately lost before being identified serologically.

Hampshire (south). Patches of dwarfed plants showing symptoms of ringspot virus infection were seen at most of the holdings visited, and arabis mosaic virus was isolated from many of the samples collected. The virus was also detected in soil collected from a typical outbreak, and it seems likely that it is widespread and indigenous in the area. At one holding the relatively rapid degeneration of plants, and their distribution in a recently-planted stock of Cambridge Favourite obtained from Norfolk, strongly suggested infection in the runner bed. Dr. B. D. Harrison later visited the runner beds in Norfolk and confirmed that the black fen soil at this site was infective.

Combe Martin. Crops seen on the steep hill slopes typical of this area were often patchy. Among the established causes for this are red core, rock outcrops and mineral toxicity. Soil-borne viruses may also be a contributing factor, for arabis mosaic virus was isolated from Cambridge Vigour and Cambridge Favourite in a patch of dwarfed plants at one holding.

Tamar Valley (Devon). The only farm visited was the source of Malling Exploit raspberry plants from which arabis mosaic virus had previously been isolated (Cadman, 1956). A patch of infected plants was observed, involving the varieties Redgauntlet, Cambridge Favourite and Cambridge Vigour. Other scattered infections in these beds were probably due to infection in the runner beds which had been sited on the same farm. Thus, at this one farm alone there are probably at least three areas of infective soil. From another farm in this area the arabis mosaic-infected stock of Cambridge Favourite mentioned in a previous paper (Lister, 1958) was obtained.

Tamar Valley (Cornwall). Two patches of plants of Cambridge Prizewinner, infected with arabis mosaic virus, were found in a large field at one holding. The site of one of these has been known to be poor for strawberry growing for many years.

Cheddar. About 40 per cent of the plants of Cambridge Favourite at one holding were infected, and their distribution strongly suggested that infection had occurred in the runner bed. A later visit to the site in Wiltshire where these plants had been propagated supported this impression.

West Midland Region. Rather large areas of infection were seen in Talisman and Royal Sovereign respectively, at two farms in Warwickshire. However, no virus was obtained from samples at a site elsewhere in the same county, where very characteristic symptoms were seen in several varieties.

Dee Valley. Here a degeneration of obscure cause, occurring in patches, has been a serious problem in strawberries for many years. At least some of this may be caused by soil-borne virus infection, for plants in a fairly typical site proved to be infected with arabis mosaic virus. However, samples from similar but more extensive areas of stunted plants seen in the Farnden and Holt districts did not yield mechanically transmissible viruses.

Other known outbreaks. Plants of several varieties showing typical ringspot symptoms, sent from a smallholding in Pembrokeshire in 1958, proved to be infected with arabis mosaic virus, which was also later isolated from soil sent from the same site.

Arabis mosaic virus was also isolated from two Cambridge Vigour plants, sent in 1959 by Mr. D. W. Robinson from County Armagh, Northern Ireland, collected from a small patch of dead and weak plants in an otherwise vigorous plantation.

DISCUSSION

Caution is needed in interpreting the results of such a limited survey as this, but since even quick one- or two-day visits to the areas mentioned revealed the presence of arabis mosaic virus infection at a number of sites, it seems likely that this virus is widespread, and of local importance in strawberries throughout England. In some cases the appearance of outbreaks and their history indicated that they were indigenous. A few were large, involving several thousand plants, but most were much smaller, and probably spreading only slowly, if at all.

The general impression gained was that so far as fruit production is concerned, soil-borne viruses are unlikely to be of direct importance, except in certain localities. However, several serious crop losses caused by the use of infected planting material were seen during the survey, demonstrating the special problems, which have been explained elsewhere (Lister, 1960a), presented by soil-borne viruses in the inspection and certification of strawberry plants for sale.

Certain soils can be made infective by cropping them with infected plants (Cadman and Harrison, 1960), and thus virus spread could occur through the growing of infected stocks of vegetatively propagated crop plants such as strawberry (Lister, 1960a). The number of infections with arabis mosaic virus found in south Hampshire suggests that the propagation of virus-infected strawberries over many years may have caused a considerable amount of virus spread there. However, it is now known that transmission of soil-borne ringspot viruses can occur through the seed of some of their hosts, including weeds (Lister, 1960b) and it is not yet clear whether this is the more important mode of spread.

It is interesting that all the isolates of ringspot viruses so far obtained from strawberry collected in England have proved to be strains of arabis mosaic virus, although tomato black ring and raspberry ringspot viruses have been isolated from other crops (Harrison, 1960). By contrast, almost all isolates from strawberry collected in Scotland have been strains of tomato black ring and raspberry ringspot viruses. Such differences are presumably due to factors influencing the distribution of the vectors of the viruses. But because arabis mosaic virus has now been detected in a range of soils, including medium shingle, heavy loam, and black fen soils, it is clear that this virus, at least, can become established in many kinds of soil. Possible control measures for soil-borne virus diseases in strawberry and raspberry have already been summarized (Lister, 1960a), and it is now more clear that basically, control will depend not only on the recognition of soil-borne virus infections for what they are, but on their accurate diagnosis.

In addition to those mentioned above, I would like to thank those officers of the N.A.A.S. and members of the staff of the research stations at East Malling and Long Ashton who co-operated in this survey, particularly Mr. L. F. Clift, Mr. J. B. Duggan, Mr. F. A. Roach and Mr. B. D. A. Tucker. I am indebted to Miss Patricia Duncan for technical assistance.

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CONTROL OF APHIDS AND RED SPIDER MITE ON YOUNG CARNATIONS UNDER GLASS

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THE control of aphids, especially *Myzus persicae* (Sulz), and *Macrosiphum euphorbiae* (Thom.), and glasshouse red spider mite, *Tetranychus urticae* (Koch), on young carnations by spraying, is not always satisfactory. During the past three years, tests have been done to compare the efficiency of several of the newer insecticides as sprays or drenches against these pests on carnation plants in a cold house.

TESTS WITH APHIDS

In 1957, tests were done on young plants of var. Pink Sim, 4–6 inches tall, growing in J.I. compost in 4-inch pots, and heavily infested with *Macrosiphum euphorbiae*. Treatments were applied to single plants replicated in four blocks. Manoxol, a succinate wetter, was added at 8 fl. oz per 100 gal to all spray treatments, and resulted in a good spray cover on the rather waxy leaf surfaces. The drenches were applied to the soil at 4 fl. oz per plant. All treatments were applied first on March 13, when aphids had begun to colonize the plants, further applications being made when necessary. Details are given in Table 1, along with counts of aphids present at varying periods after treatment. It should be noted that a second application was given to all treatments, except demeton-methyl and schradan drenches, on March 26. Schradan drenches were applied for the second time on April 10, when all other treatments, except the demeton-methyl drench, received a third application.

The sprays quickly reduced the aphid infestation to a very low level, but the effect was short-lived, and spraying had to be repeated at intervals of about fourteen days. Other heavily infested plants were present in the glasshouse during the trial, and were a source of re-infestation.

TABLE 1

Total Aphids per Four Plants after Treatment

Treatment		March 18	March 26	March 28	April 10	April 12	April 25
Material	*per cent*						
Sprays							
Demeton-methyl ..	0·0375	5	25	1	19	0	7
Endrin	0·0125	2	14	1	33	4	20
Malathion ..	0·1	4	22	1	125	0	11
Diazinon	0·02	5	29	0	60	0	86
gamma–BHC ..	0·0125	6	36	0	97	1	33
Drenches							
Demeton-methyl ..	0·025	2	0	0	0	0	0
Diazinon	0·02	185	176	106	37	41	76
Schradan	0·125	25	10	6	69	69	20
Untreated		89	149	167	165	160	215

A single drench of demeton-methyl gave a very good control after two days, and kept the plants free of aphids for at least five weeks. Schradan gave only a fair control, and its effect was much slower and less persistent; a second application was necessary after about three weeks. Systemic properties have not been claimed for diazinon, and one drench had no effect. All treated plants later flowered normally, but a very slight tip scorch to the upper pairs of leaves was noticed on the plants drenched with demeton-methyl.

The work was repeated in 1959, using drenches of demeton-methyl at a range of concentrations, and including a series of Rogor drenches. Treatments were applied on April 28 to young plants of var. Kokomo Sim growing in 5-inch pots. By the time *Myzus persicae* had built up to fair numbers the plants were well-established, and about ten inches tall. As in 1957, the drenches were applied to single plants replicated in four blocks, and to test the persistence of the treatments all clean plants were artificially reinfested with five or six aphids each, placed on the young leaves at the tops of the plants, fifteen, thirty, and forty-one days after treatment.

TABLE 2

Total Aphids per Four Plants after Treatment

Days after Treatment on April 28	Demeton-methyl, fl. oz per plant				Rogor, fl. oz per plant			Untreated
	0·025 per cent			0·0125 per cent	0·035 per cent		0·0175 per cent	
	5	*2½*	*1*	*5*	*5*	*2½*	*5*	
0	62	34	28	26	35	44	35	54
3	Live aphids still present on all treatments							
8	0	0	0	0	0	0	0	129
15	0	0	30	20	0	0	0	170
30	33	56	100	37	0	1	1	222
41	110	241	363	72	0	8	10	295
48	—	—	—	—	20	35	33	—

The results of these tests are shown in Table 2. A good control of aphids, lasting about three weeks, was obtained with a single drench of 0·025 per cent demeton-methyl at both 5 and 2½ fl. oz per plant. Although initially as effective as the higher rates, the 1 fl. oz treatment was less persistent, and the same applies to the 0·0125 per cent concentration of this material at 5 fl. oz per plant.

Rogor drenches at all the rates were slightly more effective than demeton-methyl, and plants drenched with 0·035 per cent Rogor at 5 fl. oz were still clean about five weeks after treatment. The lower rates and dosages were not so persistent.

In the trials discussed so far, drenches were applied to young, fast-growing plants where absorption of the insecticide through the roots is likely to be most favourable. To test their efficiency on older plants, drenches were applied to carnations about 20 inches tall about four weeks before they began to flower. A Rogor spray was included in this test, as this material had not been available in 1957. The concentrations, dosages, materials, and results are shown in Table 3.

TABLE 3

Control of Aphids on Plants Four Weeks before Flowering: Total Aphids per Four Plants after Treatment

Days after Treatment on May 25	Drenches at 5 fl. oz. per Plant			Spray	Untreated
	Rogor 0·035 per cent	*Demeton-methyl 0·025 per cent*	*Phosdrin 0·0125 per cent*	*Rogor 0·035 per cent*	
3	0	0	0	0	207
9	All plants artificially reinfested				
14	0	35	40	16	215
24	22	132	145	121	270

The drenches were clearly less effective when applied to older plants, and in this test a drench of demeton-methyl or Phosdrin prevented reinfestation only for about a week. The Rogor drench was effective for fourteen days, after which the test plants were successfully reinfested, but this degree of persistence was no better than the result obtained by spraying.

There have been occasional reports, from growers using demeton-methyl sprays in the Lee Valley, of a slight tip scorch on the petals after bud burst treatment. With the varieties used in these tests there has been no evidence of this, either with demeton-methyl or with Rogor when applied as a coarse wetting spray.

TESTS WITH GLASSHOUSE RED SPIDER MITE

In 1958, young plants of var. Pink Sim, about six inches tall and heavily infested with *Tetranychus urticae*, were used to test the efficiency of the treatments shown in the first column of Table 4. Manoxol at 4 fl. oz per 100 gal was added to all sprays, and the drenches were all applied at 5 fl. oz per plant. The treatments were first applied on May 5, and a second spray on May 20. Treatment effects were assessed by counting the active stages of mites present on a three-leaf sample from each plant. The counts made on the untreated plants on June 3 and 21 refer to two plants only, the other two having been killed by red spider attack.

On May 22, two days after the second spray treatment, all treated plants were appreciably better than the untreated controls. Very good results were obtained with two sprays of Kelthane, Rogor, demetonmethyl, and malathion. As expected, Phosdrin gave a good initial kill but failed to keep the plants free of mites, which built up soon after the second spray. The ovicides gave an appreciably smaller degree of control than the other compounds; Tedion, particularly as a miscible formulation, seemed to have given a slightly better control than the other ovicides by the time observations were stopped.

A single drench of Rogor or demeton-methyl gave a good control of mites for six weeks, but this effect may not be so prolonged on older plants. Schradan was not quite so effective, while Phosdrin was least effective and failed to keep the plants clean.

The uptake of systemic insecticides by plants is known to depend on many factors including soil type, age of plant, variety, temperature and humidity. The results obtained with these materials are therefore likely to vary under different conditions.

TABLE 4

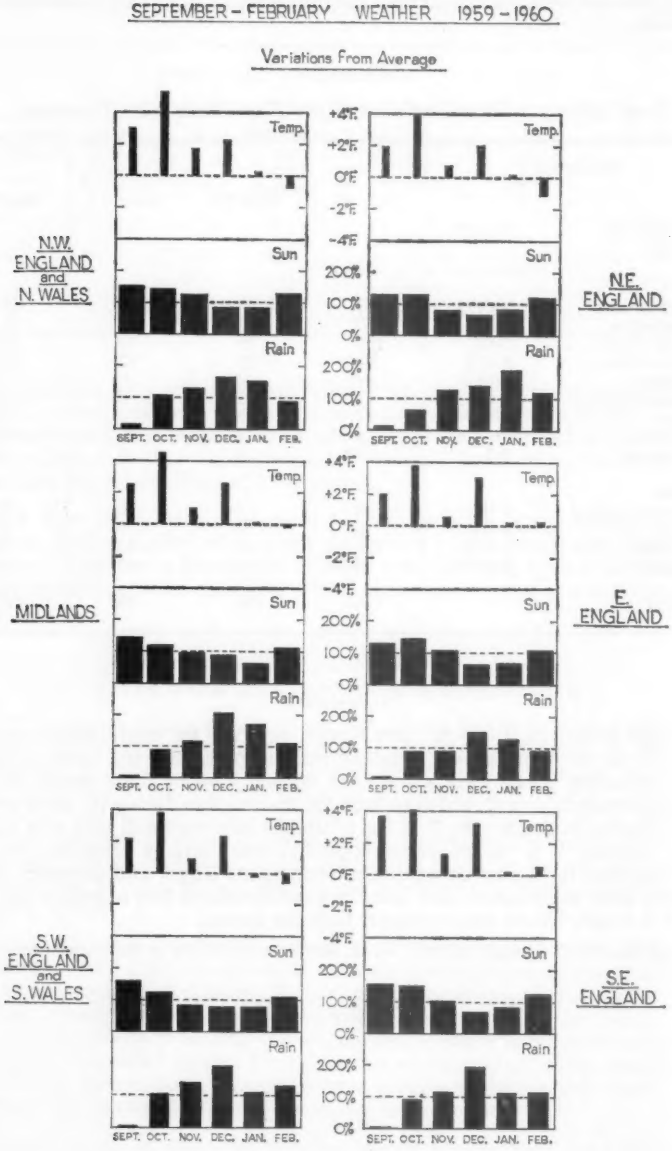
Total Mites per Three-Leaf Sample per Four Plants after Treatment

Treatment		May 12	May 22	June 3	June 21
Material	*per cent*				
Sprays					
Chlorbenside ..	0·0125	47	35	54	96
Chlorfenson ..	0·025	77	38	48	55
Tedion (W.P.) ..	0·02	100	23	30	38
Tedion (Misc.) ..	0·015	89	25	12	20
Kelthane	0·0125	54	4	0	0
Demeton-methyl	0·0375	19	1	0	0
Rogor	0·035	16	2	0	0
Phosdrin	0·0125	8	12	28	45
Malathion ..	0·1	10	0	4	0
Drenches					
Demeton-methyl	0·025	8	0	0	0
Rogor	0·035	0	0	0	0
Schradan	0·125	101	18	10	0
Phosdrin	0·0125	24	44	81	95
Untreated		116	160	(80)	(90)

SUMMARY

A single drench of 0·035 per cent Rogor, or 0·025 per cent demeton-methyl, at 4–5 fl. oz per plant, gave a good control of aphids and red spider mites on young carnation plants over a 4–6 week period. Two or three sprays of these and other materials were needed to keep the plants clean during the same period. There is some evidence that 2½ fl. oz of drench per plant will also give a satisfactory result; 1 fl. oz of demeton-methyl was initially effective, but less persistent than the higher dosages. On older plants Rogor and demeton-methyl drenches were less effective, and failed to keep the plants free of aphids for more than 1–2 weeks, which was no longer than the sprays.

I thank Dr. H. C. Gough and Mr. W. H. Read for their help in the preparation of this paper.


SEPTEMBER – FEBRUARY WEATHER 1959 – 1960
Variations From Average
N.W. ENGLAND and N. WALES
N.E. ENGLAND
MIDLANDS
E. ENGLAND
S.W. ENGLAND and S. WALES
S.E. ENGLAND
Temp.
Sun
Rain
+4°F.
+2°F.
0°F.
-2°F.
-4°F.
200%
100%
0%
SEPT. OCT. NOV. DEC. JAN. FEB.

THE WEATHER OF ENGLAND AND WALES*

AUTUMN AND WINTER 1959–60

As is often the case when the weather has been hot and dry, the outstanding summer of 1959 lasted well into the autumn. September was sunny and warm and also exceptionally dry. By the end of the month a few stations in the Midlands and East Anglia had had no measurable rain for forty-eight days. An extreme temperature of 86°F was recorded at Gatwick on the 11th. It continued to be warm in October, when mean monthly temperatures were 4°F or more above average. The first half of the month was sunny, but changeable weather with gales followed and most areas experienced normal amounts of rain. Over England and Wales the total general rainfall for the May to October period was the lowest since before 1870, and probably since 1750. November was also changeable and rather mild with rainfalls slightly above average, heavy rains occurring in the last fortnight.

The first month of winter still maintained mild conditions, but was also wet and stormy, the wettest, in fact, for twenty-five years over the country as a whole. As a result, the annual rainfall totals were large enough in most places to mask the long dry spell in summer. January was dull and wet, with a cold snowy period in the middle of the month. Temperatures were lowest from the 13th to the 16th with day maxima often below freezing point. Nevertheless mean monthly temperatures were near average. A similar weather pattern prevailed in February, with a cold spell from the 10th to the 20th, and ending with very mild weather, day temperatures exceeding 60°F in many places.

The weather for each of six months, September to February, inclusive, is represented graphically on page 110 figures for the six districts of England and Wales are shown in terms of the deviation from the average of air temperature, sunshine and rainfall. The main features are the high average temperatures from September to October, the extreme dryness of September and the rains of early winter. Not shown in these diagrams is the persistent warmth in the soil, which continued to be above average throughout most of the period.

NEW OR UNCOMMON PLANT DISEASES AND PESTS

Lucerne Rust in England. In autumn 1959, the rust *Uromyces striatus* Schröt. was found affecting four East Sussex stands of Du Puits lucerne, *Medicago sativa* L., all but one in the sowing year. Stem and leaf sori were common on most of the plants in a rather poor six-acre crop at Lewes, not yet cut for the first time, on September 24. A few leaf sori were then also found on strong regenerating growth in an adjoining eight-acre 1958-sown crop, and on vigorous young plants in a partially grazed eighteen-acre field at Iford, two miles away but under the same management. On October 20, in a young seven-acre stand at Crowhurst, near Hastings, there were sori on the leaves of sparse regenerating growth, but

* These notes, and the diagrams on page 110, are provided by the Agricultural Branch of the Meteorological Office, and are published by permission of the Director-General.

more on hard stems denuded of foliage by grazing—before which incidence must have been at least as high as in the worst affected crop at Lewes.

Leaf sori, present on both surfaces but more common on the lower, were approximately circular, 0·1–0·6 mm in diameter, cinnamon brown when fresh and sometimes surrounded by a chlorotic halo; those on stems were ellipsoid, up to 2 mm long, and darker. Some sori consisted of uredospores or teleutospores alone; but in many both occurred, the latter (more common on stems, in the larger sori, and among the later collected Crowhurst material) apparently succeeding the former as autumn advanced. Both types of spore were found to agree closely with earlier accounts of *Uromyces striatus* on *Medicago* spp. The uredospores (Plate II, 1, *left*) were globoid or broadly ellipsoid, 16–21 × 18–25μ; with wall 1·5μ thick, golden brown, appearing smooth at maturity but with minute echinulations visible on immature spores; germ pores usually four, sometimes with hyaline caps. The teleutospores (Plate II, 1, *right*) were broadly ellipsoid (often angular) or ovoid, 13–18 × 18–22μ; with wall 1·5μ thick, cinnamon brown (up to 7μ and paler over apical germ pore) with longitudinally striate sculpturing; pedicel short, fragile, hyaline.

Uromyces striatus is common on lucerne in various parts of the world, but has hitherto been recorded on this host only once in Britain—near Tuddenham, West Suffolk, in 1957 (G. M. Butler, *Trans. Brit. mycol. Soc.*, 1958, 41, 401–4). British records on other hosts have been collated and discussed by Glasscock and Ware (*Trans. Brit. mycol. Soc.*, 1946, 29, 267–9), Wilson and Bisby (*Ibid*, 1954, 37, 80), Moore (*British Parasitic Fungi*, 1959, Cambridge Univ. Press, 406), and Butler (loc. cit.), who has confirmed the connection of aecidia on *Euphorbia cyparissias* L. with *U. striatus* and indicated its possible identity with other rust species.

W. T. DALE

***Trypodendron domesticum* damaging plum trees.** This scolytid is usually associated with oak, beech and birch (Balachowsky, A., *Faune de Fr.*, **50,** 198). Munro, J. W. (*For. Comm. Bull.* No. 8, 1926, 59–60) includes ash, alder and hawthorn. Stark (*Bark Beetles of U.S.S.R.*, 1952, 363–4) gives oak, sycamore, alder, beech, hornbeam, walnut, rowan, mulberry, acacia and wing nut as hosts in Russia. Infestation is usually considered to be a secondary effect of damage to the trees, notably by storm or fire. On June 25, 1959, a piece of main trunk of a plum tree was received from Knockando, Morayshire, which showed extensive mining of the sapwood by this wood-boring species, *Trypodendron domesticum* L. Several of the adult beetles were found in the sapwood, and the occurrence of small patches of fine sawdust on the surface of the bark indicated adult emergence at the time. No larvae or pupae were found. In general, the main gallery (1½ mm diameter) into the wood from the bark extended for about 1 inch, and galleries at right angles to these were about 1½ inch in length. Three Victoria plums (two 14 and one 7 years old) and one greengage (7 years old) were affected. The damaged trees had become unprofitable to keep, but they were still producing foliage and fruit. Although the injury was usually in the main trunk, their lack of vigour was not considered to be due primarily to insect injury. It is possible that the infestation was caused by an increase in the local population of *T. domesticum* following the great gale of January 31, 1953 (see Steven, H. M., *Nature. Lond.* 1953, 171, 454–6), which caused serious damage to beech, although within the immediate vicinity of the plum trees there was not a large amount of beech which had been wind blown. I thank Mr. E. A. J. Duffy, of the Commonwealth Institute of Entomology, for confirming the identification.

M. W. SHAW

***Rhynchosporium orthosporum* on Italian Ryegrass.** In the second week of March 1960, stunted plants of S22 and H1 strains of Italian ryegrass, *Lolium multiflorum*, were seen in a nine-acre field at Wadhurst, East Sussex. The foliage was chlorotic, with the older leaves brown and shrivelled. Affected plants were in several patches about one or two yards in diameter. Examination of individual leaves showed light green or greyish areas with irregular dark-brown margins and bearing cylindrical conidia which were mostly one-septate (Plate II, 2). Conidia appeared to arise directly from the mycelium, and varied in size from 15–25 × 2·5–5·4μ. The average size of twenty conidia in water was 20·0 × 5·0μ. The appearance and size of the conidia agreed closely with those of *Rhynchosporium orthosporum* causing leaf blotch on cocksfoot (Owen, H., *Plant Pathology*, 1952, **1**, 122), and the identity of the fungus on ryegrass was confirmed by Dr. Owen. By mid April the disease had become distributed throughout the crop, with a high proportion of plants affected. By the end of the month, however, new growth was normal and diseased plants were difficult to find.

This is the first record of *R. orthosporum* on *Lolium* in Britain, although it has been recorded on *Lolium multiflorum* and *L. perenne* in the U.S.A. (Sprague, R., *Plant Dis. Rptr. Supp.* 134, 1942). Dr. I. G. Thorpe of Bristol informs me that he also found the fungus on *L. multiflorum*. *Agrostis stolonifera*, and *Dactylis glomerata* in an old ley at Compton Chamberlayne, Wiltshire, on April 1, 1960. His record on *Agrostis* is the first in Great Britain.

H. J. WILCOX

***Rhynchosporium secalis* on Westerwolths Ryegrass.** A severe infection by *Rhynchosporium secalis* (Oudem.) J. J. Davis was observed on *Lolium multiflorum* var. Westerwoldicum at Compton Chamberlayne, Wiltshire, on April 1, 1960. The grass was sown in September in a sheltered field following Rika barley. Die-back of the leaf blades was first seen by the farmer in early February, and it continued until the crop was grazed in early April. Characteristic *Rhynchosporium* lesions were found at the tips of the leaves and towards the middle of the laminae. Die-back followed the enlargement and coalescence of these lesions. Microscopic examination revealed one-septate conidia with beaked upper cells, typical of *Rhynchosporium secalis*. These averaged 16μ × 4μ (range 13·6–21·2μ × 3·0–4·5μ). The identification has been confirmed in culture by Dr. H. Owen of the Department of Agricultural Botany, University of Reading. The Plant Pathology Laboratory at Harpenden has a record, from Mr. N. C. Preston, of *R. secalis* on a crop of Italian ryegrass at Ruyton of the Eleven Towns, Salop, in the spring of 1955.

I. G. THORPE

Powdery Mildew on Carrots. During September 1959, the foliage of two field crops of carrot growing on black fen soil at Warboys, Hunts, were observed (J. H. H.) to be affected by a species of *Oidium*. From a distance the foliage of both crops appeared white in colour. Most plants carried some infection, and on many the foliage was white with spores. No loss of crop was apparent, although some premature death of foliage resulted from the mildew, because at the time of attack the plants had already produced sizeable roots. The conidia obtained from the material were markedly cylindrical in shape and measured 30–51 × 9–15μ (mean 29 × 13μ). No perithecia were found on the foliage. Almost simultaneously—about mid September 1959—a similar *Oidium* was seen (D. H. P.) for the first time on a crop of carrots in Jersey, and within a week or two the disease was found on crops throughout the island. Again no perithecia were seen.

There is no previous record of a powdery mildew on carrot in Great Britain. *Erysiphe umbelliferarum* de Bary has been recorded on *Daucus carota* from

Switzerland, Roumania, and Russia by Blumer (*Die Erysiphaceen Mitteleuropas*) and from Holland (*Versl. PlZiekt. Dienst Wageningen*, 1950, No. 117, 41). *Erysiphe polygoni* DC. was noted from the Sudan (Boughey, A. S., *Mycol. Pap.*, 1946, No. 14). An *Oidium* has been recorded on carrots in Israel (Palti, J., *Plant Dis. Reptr*, 1959, **43**, 221–6). It is probable that the *Oidium* observed belongs to *E. polygoni* of which *E. umbelliferarum* can be considered to be a synonym.

J. H. HAWKINS and D. H. PHILLIPS

CONTROL OF THE STRAWBERRY AND CYCLAMEN MITE WITH THIODAN

by T. J. LEGOWSKI

National Agricultural Advisory Service, Cambridge

IN the U.S.A., Allen, Nakakihara and Schaefers (*J. Econ. Ent.*, 1957, 50, 648–52) have shown endrin to be the most effective material to use against strawberry mite *Steneotarsonemus pallidus* (Banks), while azobenzene and Thiodan, used in only one experiment, gave also promising results. In Britain, there is no published information on the effect of any of the newer synthetic materials on this mite.

In 1959, a small experiment was carried out at Cambridge with Thiodan against strawberry mites. Six potted plants (Royal Sovereign), each heavily infested, were taken from a nursery growing early dessert fruit in a glasshouse. At the end of May three of the plants were thoroughly sprayed with 1·2 pints (0·7 litre) of 0·05 per cent Thiodan through a hand sprayer, while the other three plants were left as unsprayed controls. Approximately 2 ml of a succinate wetter were added to the spray. All plants were kept together in a glasshouse, and the results were assessed eighteen days later by counting the mites on three young leaves, taken from within the crown of each plant.

There were two mites on the sprayed plants (2, 0, 0) and 202 mites on the unsprayed (123, 39, 40). There was also a marked difference in the appearance of the treated and the untreated plants (Plate III, 2); this was noticeable a few days before the counts, and it persisted through most of the season in spite of the close proximity of the infested controls.

(80253) Wt. 27 K.9 9/60 Hw.